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ENVIRONMENT AND WATER RESOURCES

FRACTURED BEDROCK AND ALLUVIUM GROUNDWATER REMEDIATION FEASIBILITY STUDY

MISSOURI ELECTRIC WORKS (MEW) SITE

PREPARED FOR:

MEW Site Trust Fund Donors

C/O Ameren Services

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
1,2-DCB	1,2-dichlorobenezene
1,2-DCE	1,2-dichloroethene
1,2,4-TCB	1,2,4-trichlorobenzene
1,3-DCB	1,3-dichlorobenzene
1,4-DCB	1,4-dichlorobenzene
ARAR	Applicable or Relevant And Appropriate Requirements
ASL	above sea level
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CAA	Clean Air Act
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COCs	constituents of concern
COPCs	constituents of potential concern
CTE	central tendency exposure
CWA	Clean Water Act
°	Degrees
ERT	electrical resistivity tomography
EPM	Equivalent Porous Medium
ESD	Explanation of Significant Differences
FS	Feasibility Study
feet/d	feet per day
FRTR	Federal Remediation Technologies Roundtable
GRAs	general response actions
GTARCs	Groundwater Target Concentrations
ha	Hectare
HI	Hazard Index
HQ	Hazard Quotient
IC	Institutional Control
ILCR	Incremental Lifetime Cancer Risk
km	kilometer

km^2	square kilometers
Komex	Komex H2O Science, Inc.
L	liter
m	meters
m/d	meters per day
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	method detection limit
MDNR	Missouri Department of Natural Resources
MEW	Missouri Electric Works
mi	mile
MNA	monitored natural attenuation
MW	monitoring well
NCP	National Oil and Hazardous Substances Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
OSWER	Office of Solid Waste and Emergency Response
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
%	percent
POTW	publicly owned treatment works
ppm	parts per million
PRGs	Preliminary Remediation Goals
RACER	Remedial Action Cost Engineering and Requirements
RAOs	remedial action objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RL	reporting limits
RME	reasonable maximum exposure
ROD	Record of Decision
SDWA	Safe Drinking Water Act
STD	Site Trust Fund Donors
SVOCs	semi-volatile organic compounds
TBC	To Be Considered
TCE	trichloroethene
TCLs	target cleanup levels

TI	Technical Impracticability
TSCA	Toxic Substances and Control Act
TU	tritium units
ug/L	micrograms per liter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOCs	volatile organic compounds
WQS	water quality standards

1 INTRODUCTION

This report presents the results of the Fractured Bedrock and Alluvium Groundwater Remediation Feasibility Study (FS Report) for impacted groundwater within fractured bedrock and alluvium, and was prepared by Komex-H2O Science, Inc. (Komex) on behalf of the Missouri Electric Works (MEW) Site Trust Fund Donors (STD), for the MEW Site (Site) in Cape Girardeau, Missouri. For the purposes of this report, the "Site" is defined by the area of soils that were previously impacted by polychlorinated biphenyls (PCBs) above Site-specific cleanup levels, as documented in the Record of Decision (ROD) (USEPA, 1990) (**Appendix A**).

The first Draft of this report was submitted to the United States Environmental Protection Agency (USEPA) on July 30, 2004. The first Draft was submitted in conjunction with the Draft Groundwater Remedial Investigation (Komex, 2004a), the Draft Groundwater Modeling Report (Komex, 2003a), Revised Groundwater Flow and Transport Supplemental Modeling Letter Report (Komex, 2004b), and Final Baseline Human Health Risk Assessment Report (Komex, 2004c). The July 30, 2004 Draft FS considered both the fractured bedrock and the alluvium.

In response to USEPA comments on the aforementioned reports in November 2004, revised versions of the submittals were jointly transmitted which documented the results of investigations at the Site which were evaluated and discussed, and supported a risk management decision for the selection of an appropriate remedy for the Site. The revised FS Report was submitted on January 24, 2005, and only considered the fractured bedrock. The January 24, 2005, FS Report was to be read in conjunction with the Groundwater Remedial Investigation Report (Komex, 2005a), the Groundwater Flow and Transport Supplemental Modeling Letter Report (Komex, 2005b), and the Final Baseline Human Health Risk Assessment Report (BHHRA) (Komex, 2005c).

Comments were provided for the above referenced documents during meetings with the USEPA on April 8, April 27 and April 28, 2005 and each of the documents have been revised to incorporate the agency comments. These revised documents present the results, evaluation, discussion and conclusions of investigations at the Site and support a risk management decision for selection of an appropriate remedy for the Site. The significant revision to the FS Report was to re-include those portions of the text related to the alluvium, originally included in the July 30, 2004, FS Report, but removed from the January 24, 2005, version of the FS report. This FS Report, which includes both the fractured bedrock and alluvium, is to be read in conjunction with the Groundwater Remedial Investigation Report (RI Report) (Komex, 2005d), the

Groundwater Flow and Transport Supplemental Modeling Letter Report (Komex, 2005e), and the Final Baseline Human Health Risk Assessment Report (BHHRA) (Komex, 2005f).

This FS Report follows the guidelines for preparing a feasibility study report provided in the Guidance for Conducting Remedial Investigations, and Feasibility Studies Under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA [USEPA/540/G-89/004])) dated October 1988 (USEPA, 1988a). This FS Report was prepared and completed in accordance with the Consent Decree (CD), which went into effect on March 9, 1998.

1.1 PURPOSE AND ORGANIZATION OF THE FS REPORT

The purpose of the FS Report is to present a range of groundwater remedial alternatives for the fractured bedrock and alluvium to address the risks to human health as identified in the BHHRA report (2005f). The FS Report will provide technical documentation to support the USEPA selection of a remedy to be included in the revised ROD.

The FS Report has two principal objectives:

1. Develop a range of remedial alternatives that addresses identified human health risks resulting from impacted Site groundwater in fractured bedrock and alluvium; and
2. Demonstrate satisfaction of the CERCLA remedy selection requirements. To meet this objective a detailed analysis of the remedial alternatives against a set of nine evaluation criteria is required to allow for the selection of an appropriate remedy for Site groundwater in fractured bedrock and alluvium.

This FS Report is organized into the following sections:

- **Section 1.0 - Introduction.** Describes the purpose of the FS and provides background information such as Site description, history, previous environmental activities completed, as well as provides a summary of the Site hydrogeology, nature/extent of contamination, and mechanisms for dissolved phase constituents of potential concern (COPCs) migration. In addition, this section also presents a summary of the BHHRA conclusions.
- **Section 2.0 - Identification/Development of Applicable or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered (TBC) Guidelines, Remedial Action Objectives (RAOs), General Response Actions (GRAs).** Presents the factors considered in assessing the need for remediation and identifying possible GRAs, as well as the Site RAOs, based upon the identified constituents of concern (COCs) and target cleanup levels (TCLs).

In addition, volumes of impacted groundwater in the modeled sources areas on the Property are estimated in this Section.

- **Section 3.0 - Screening and Evaluation of Technologies and Process Options.** Presents both a preliminary identification and screening of remedial technologies and process options for fractured bedrock and alluvial groundwater, and a more detailed evaluation of selected remedial process options for fractured bedrock and alluvial groundwater.
- **Section 4.0 - Development of Remedial Action Alternatives.** Provides the rationale for the development of the remedial alternatives, and describes the alternatives developed.
- **Section 5.0 - Detailed Analysis of Alternatives.** Presents an analysis of remedial alternatives in accordance with the set of nine evaluation criteria described in the National Oil and Hazardous Substances Contingency Plan (NCP). This section also presents a comparative analysis between the various alternatives.

1.2 BACKGROUND INFORMATION

The Site-specific soil cleanup levels, as documented in the ROD (USEPA, 1990) that define, for the purposes of this report, the area of the Site, were 10 parts per million (ppm) PCBs for soils to a depth of 4 feet below ground surface (bgs), and 100 ppm at depths greater than 4 feet bgs.

For the purposes of this report, the physical extent of the property where MEW conducted operations will be referred to as "the Property". The Site includes an area on and off the Property and has a total surface area of approximately 6.8 acres. In addition to the terms "the Site" and "the Property", reference may be made to the "Study Area", which is defined to include all of the Property, all of the Site and areas outside of the Site, where remedial investigative actions have been performed.

A description of the Property and Property history is summarized below. A detailed description is provided in the Draft Groundwater Design Investigation Work Plan (Komex, 2002a).

1.2.1 PROPERTY DESCRIPTION

The Property is located at 824 South Kingshighway in a commercial area of Cape Girardeau, Missouri. The Site location map is provided as **Figure 1.1**. The Property occupies a 6.4-acre tract of land, which is bound to the north and east by retail and office properties, to the south by retail properties and to the west by South Kingshighway.

South Kingshighway provides access to the Property via an asphalt-paved drive that lies in front of a single concrete building and extends partway around the south side of the Property. The building occupies the northwest corner of the Property and is currently used by the owner to store equipment. The remainder of the Property consists of gravel-paved roads, grass covered areas, and wooded ravine and fence line areas.

1.2.2 SITE HISTORY

MEW operated at this Property between 1953 and 1992. During this operational period MEW sold, serviced, and rebuilt transformers, electrical motors, and electrical equipment controls. Operations included recycling of materials from old equipment and the recovery of copper wire and dielectric fluid from transformers. In total, approximately 16,000 transformers were repaired or scrapped at the Property during the period of operation. Approximately 90 percent (%) of the transformers dielectric fluid was recovered and filtered through Fuller's Earth prior to reuse. Some dielectric fluid is unaccounted for and it is estimated that the total volume of unaccounted dielectric fluid is on the order of 28,000 gallons.

1.2.2.1 Regulatory History

The regulatory compliance and litigation history of the Site is summarized below. A detailed discussion of the Site regulatory history is presented in the ROD (USEPA, 1990).

- **October 1984** - The Missouri Department of Natural Resources (MDNR) inspected the MEW facility and discovered leaking drums containing dielectric fluid. Elevated concentrations of PCBs were detected in oil-stained soil samples collected during the inspection.
- **November 1984** - The USEPA, pursuant to the Toxic Substances and Control Act (TSCA), inspected the MEW facility and found that MEW handling and storage procedures for oils containing or contaminated with PCBs did not conform to regulations. Soil sample results indicated elevated concentrations of PCBs.
- **August 2, 1988** - The USEPA issued an Administrative Order requiring MEW to perform several response actions, specifically to notify the public of the contamination; minimize the exposure of the public to PCB-impacted dust, soil or sediment; and minimize the amount of PCB-impacted soil migrating from the Site in surface water runoff. The USEPA erected barriers across the drainage ditches to reduce the migration of PCB-impacted soil offsite.
- **December 30, 1988** - Administrative Order on Consent between MEW Steering Committee and the USEPA (Docket No. 7-89F-002).
- **February 21, 1990** - The Site was listed on the National Priorities List (NPL).

- **September 28, 1990** - The USEPA issued the ROD, which set forth the selected soil and groundwater remedies for the Site, including onsite incineration for the cleanup of PCB-impacted soil, a pump and treat system to treat impacted groundwater, and additional investigations to identify data that would be necessary for the design of the groundwater remediation system.
- **December 30, 1991** - A Consent Decree (CD), signed by the USEPA, the MDNR, 175 Settling Defendants, and three federal agencies, was filed with the Federal Court for the Eastern District of Missouri, Southeastern Division.
- **August 29, 1994** - The Federal Court for the Eastern District of Missouri, Southeastern Division approved the CD.
- **October 1994** - CD entry was appealed by a group of non-settling former MEW customers.
- **February 1, 1995** – The USEPA issued an Explanation of Significant Differences (ESD) to the ROD, which documented primary changes to the ROD, including changing onsite incineration to onsite thermal desorption and defining onsite thermal treatment to be either incineration or thermal desorption.
- **August 1995** - The 8th Circuit Court of Appeals reversed the entry of the CD and remanded the CD to the Federal District Court for further deliberation.
- **August 14, 1996** - The CD was approved a second time by the Federal District Court. The same group of former customers again appealed the CD entry.
- **December 1997** - The Eight Circuit Court of Appeals confirmed the entry of the CD.
- **March 9, 1998** – The CD entered into effect.

1.2.2.2 Previous Site Investigations and Remedial Activities

Numerous site investigations and limited remedial activities have been conducted at the Site since 1987; these are summarized below. Additional information/data relating to these activities is provided in the RI Report (Komex, 2005d).

- **1985 Investigation. March 31, 1986 CH2MHill**
- **1987 - Ecology and Environment**; In response to the USEPA-directed field investigation program, six groundwater monitoring wells were installed at the Property (monitoring wells MW-1 to MW-6) (**Figure 1.2**). Monitoring wells MW-1, MW-2, MW-5, and MW-6 were installed in the surficial loess deposits at depths not exceeding 41 feet bgs. Monitoring wells MW-3 and MW-4 were installed in the Plattin Limestone at depths not exceeding 60 feet bgs. Wells MW-1 and MW-2 have since been abandoned; the abandonment dates were not documented.

- **1988 - USEPA**; Erected barriers across the drainage ditches to reduce the migration of PCB-impacted soil offsite.
- **1990 - Earth Tech**; Installed five monitoring wells (MW-6A, MW-7, MW-8, MW-9, and MW-10) (**Figure 1.2**). These wells were all completed in the Plattin Limestone at depths not exceeding 63 feet bgs, the first significant groundwater-bearing zone encountered at the Site.
- **1991 - Earth Tech**; Installed two additional groundwater monitoring wells in the Plattin Limestone (MW-11 and MW-11A) (**Figure 1.2**). Well MW-11 was installed to a depth of 120 feet bgs, and well MW-11A was installed to a depth of 405 feet bgs.
- **Between July 1999 and July 2002 - Williams Environmental Services, Inc**; In accordance with the ROD (USEPA, 1990) completed a remedial action, which included the excavation and remedial treatment of PCB-impacted soils from surface to a maximum depth of 27 feet bgs at the Site. Impacted soils were treated by thermal desorption to a cleanup level of 10 ppm for surface and subsurface soil.
- **June 2000 - Komex**; Conducted a geologic and hydrogeologic investigation at and within the vicinity of the Site (Komex, 2001a). The following tasks were conducted as part of this investigation:
    - Site reconnaissance and field mapping;
    - Fractured rock lineament study;
    - Groundwater and sediment sampling from groundwater monitoring wells;
    - Laboratory analyses of groundwater and sediment samples;
    - Installation of three groundwater data loggers in groundwater monitoring wells MW-3 (screened from 21 to 31 feet bgs), MW-11 (screened from 115 to 120 feet bgs), and MW-11A (open below 319 feet bgs);
    - Quarterly collection of data logger data which recorded groundwater levels and precipitation measurements;
    - Initial bedrock fracture modeling; and
    - Initial groundwater conceptual model development.
- **September 30, 2000**; Well MW-8 was abandoned due to a damaged wellhead.
- **April 2001**; Quarterly groundwater monitoring undertaken by EarthTech ceased in 1991 (EarthTech, 1991). Komex re-initiated an ongoing quarterly groundwater-monitoring program in late 2000 and quarterly monitoring reports were prepared throughout 2001 (Komex, 2001b; Komex, 2001c; Komex, 2002b). In 2002, the first two quarters of groundwater monitoring data were incorporated into the Draft Groundwater Design

Investigation Work Plan (Komex, 2002a) with subsequent monitoring results distributed as data packages (Komex, 2003b; Komex, 2003c; Komex, 2003d; Komex, 2003e).

- **Between November 2002 and October 2003**; Komex, in accordance with the Draft Groundwater Design Investigation Work Plan (Komex, 2002a), conducted a two-phase groundwater design investigation. Results of this investigation are presented in the RI Report (Komex, 2005d). The following tasks were conducted as part of this two phase investigation:
  - Assessment of Site hydrological characteristics through analysis of the well hydrographs in combination with precipitation data;
  - Geoprobe investigation to assess and refine the geophysical interpretation;
  - Geophysical electrical resistivity tomography (ERT), seismic reflection and refraction assessment on and to the southeastern extent of the Site, in the vicinity of the well clusters (MW-3/5/11/11A), to enhance the understanding of the fracture networks and flow regime and to identify target locations for the installation of future groundwater monitoring wells;
  - Installation and subsequent groundwater and sediment sampling of three groundwater-monitoring wells (MW-12, MW-13 and MW-14) (**Figure 1.2**), located in the southeast corner of the Site. The locations of the wells were based on the findings of the geoprobe investigation and geophysical assessment. The monitoring wells were completed within the fractured limestone at depths of between 57 and 95 feet bgs and have been monitored over nine events to date;
  - Additional geophysical surveys (electrical resistivity and seismic velocity) to the southeast of the Site, which includes the wetland area, were undertaken to: 1) identify fracture networks potentially connected to the Site; 2) define basement topography, and 3) identify target locations for the installation of groundwater monitoring wells to provide constraints for groundwater modeling and target probable impacted locations;
  - Advancement of eleven boreholes to assist in guiding groundwater monitoring well installation. Boreholes BH-15B1 through BH-15B5 were advanced to assist in locating wells MW-15A and MW-15B; boreholes BH-16A1 and BH-16B1 were advanced to assist in locating the MW-16 well cluster; and, boreholes BH-17B1 through BH-17B4 were advanced to assist in locating wells MW-17A and MW-17B.
  - Installation and groundwater sampling of eight additional groundwater-monitoring wells (MW-15A, MW-15B, MW-16A, MW-16B, MW-16C, MW-17A, MW-17B and MW-18) (**Figure 1.2**) located south of the Site and within the wetland area. Wells MW-16A, MW-16B, MW-16C, MW-17A, and MW-18 were completed within alluvial deposits, and

wells MW-15A, MW-15B and MW-17B were completed within the fractured limestone. These wells were sampled in September and October, 2003;
  - Installation of a groundwater piezometer, MEW-E1, in the drainage way southeast of the Property;
  - Installation of groundwater data loggers in groundwater monitoring wells MW-16A and MW-16C to determine vertical groundwater flow in the wetland area; and
  - Update of the conceptual model.
- **2004** - Komex conducted an additional investigation, which involved the installation of five groundwater monitoring wells (wells MW-20A, MW-20B, MW-20C, MW-21A and MW-21B) in the alluvial sediments in the wetland area, to the southeast of the Site (**Figure 1.2**). The investigation was designed to study the movement of COPCs within the alluvium. Groundwater monitoring was also conducted in February, May, August and November of 2004.

1.3 SITE PHYSICAL CHARACTERISTICS

The following is a summary of Site physical characteristics as described in the RI Report (Komex, 2005d).

1.3.1 SURFACE FEATURES

The Property is situated on top of a flattened ridge that runs approximately southwest to northeast (**Figure 1.3**). This ridge separates the valley of the Cape LaCroix Creek to the north and a low-lying wetland area to the south. A small creek (Wetland Creek) flows eastwards across the wetland area and joins the Cape LaCroix Creek approximately 0.7 miles (1.13 kilometers [km]) east of the Property. The Cape LaCroix Creek joins the Mississippi River 1.5 miles to the southeast of the Property.

Ground surface elevation at the Property is approximately 405 feet above sea level (ASL). To the south of the Property, the ground slopes downwards to Wilson Road, which forms the northwestern boundary of the wetland area (**Figure 1.3**). The elevation of the wetland area varies from 360 feet ASL at Wilson Road, to 351 feet ASL at the Cape LaCroix Creek. To the north of the Property, the ground slopes downwards to the relatively flat valley bottom of the Cape LaCroix Creek. Runoff channels, located near the northern, southern, and eastern boundaries of the Property, drain towards the wetland area to the southeast of the Property.

1.3.2 METEOROLOGY

Cape Girardeau's climate is continental, due to its central location within the United States of America. Temperature in this region is subject to frequent fluctuation. Between 1971 and 2000, recorded temperatures varied between 24°F and 90°F seasonally, and averaged at 57.2°F daily. For the same period, annual precipitation has averaged at 46.5 inches and monthly precipitation has averaged between 3.2 inches and 5.1 inches. The wettest months are typically March through May, November, and December. Snowfall occurs between October and April, averaging 12.8 inches annually.

1.3.3 SURFACE WATER HYDROLOGY

The Property is a topographical high ridge in the area. Subsequently, during precipitation events that exceed the infiltration capacity of the soil, runoff occurs from the Site. A runoff channel is located near the eastern boundary of the property, which drains southeast via a gully located on the Property, toward Wilson Road. Several drainage ditches then conveys storm water from Wilson Road to the Wetland Creek and retention pond, approximately 540 feet to the south. **Figure 1.4** illustrates the off-Property surface runoff pathways, as they were observed during a storm event in June 2003.

The Wetland Creek, which flows south of the Property, originates at a retention pond located approximately 0.3 miles west of the Property, at an elevation of 393 feet ASL (**Figure 1.3**). The Wetland Creek flows southeast for approximately 0.36 miles, crosses under South Kingshighway and then follows an engineered course across the flat valley bottom to the southeast of the Property, at an elevation of approximately 350 feet ASL, before discharging into the Cape LaCroix Creek (**Figure 1.3**).

A retention pond has been constructed adjacent to the Wetland Creek, southeast of the Property. Observed water levels in the retention pond are very similar to those measured in the Wetland Creek, suggesting a significant hydraulic connection between the two water bodies.

The Cape LaCroix Creek flows eastward through a valley that lies north of the Property, then turns south, passing the eastern end of the Property ridge before flowing southeast to the Mississippi River.

1.3.4 GEOLOGY

1.3.4.1 Regional Geology

The Site is situated within the southeastern part of Missouri, which contains exposures of geologic formations ranging in age from Paleozoic to present time. Older Paleozoic exposures are mostly confined to the Ozark Plateau region, which is located in the southwestern part of Missouri.

Southeastern Missouri consists of mostly unfolded shallow dipping beds except in regions where faulting has occurred. Faulting within the State was most prevalent in the pre-Pennsylvanian period. The geological faults common to Missouri average a displacement distance of 100 feet. At least six episodes of major deformation and uplift have been recognized which include the following geologic periods:

- Precambrian;
- Early Ordovician;
- Post-Early Devonian/Pre-Mississippian;
- Post Mississippian/Pre-Pennsylvanian;
- Post Pennsylvanian; and
- Tertiary.

1.3.4.2 Local Geology

In the Cape Girardeau area, the uppermost formation is commonly a surficial, undifferentiated Pleistocene age loess deposit that consists predominantly of loosely consolidated silts and silty clays. Where the loess is encountered, it may vary in thickness up to 30 feet. The loess was deposited during an eolian erosional and depositional period during the Pleistocene age and lies on top of the Ordovician age limestone bedrock units of Cape Girardeau.

The Ordovician age limestone bedrock units of Cape Girardeau dip toward the northeast at a maximum of 2 degrees. The bedrock units contain numerous faults that are not classified as being seismically active; the Cape Girardeau area, however, is approximately 25 miles to 30 miles from the epicenter line of the New Madrid area earthquakes. The Cape Girardeau fault is located approximately 1-mile east-northeast of the Site. The Cape Girardeau fault strikes north 100 west, the eastern side downthrown with a displacement of 40 feet.

Near the Property, the loess deposits are underlain by the Plattin Formation. The Plattin Formation is a slightly dolomitic and fossiliferous limestone, with a thickness in excess of 400 feet. At the base of the Plattin Formation, a conglomeratic and oolitic limestone is often encountered. The Rock Levee Formation, which underlies the Plattin Formation, may vary in thickness between 250 feet and 300 feet. The Rock Levee Formation consists predominantly of alternating, dense layers of limestone and dolomite.

The Joachim Formation underlies the Rock Levee Formation and is approximately 170 feet thick. The Joachim Formation outcrops approximately 1.2 miles to the southwest of the Property.

1.3.4.3 Near Site Geology

Geology at the Site and surrounding areas consists primarily of loess, "terrace" and "alluvial" deposits underlain by Plattin Formation Limestone (bedrock). A detailed discussion of the geologic conditions present at the Site and surrounding areas is presented in the RI Report (Komex, 2005d). The general characteristics of the surficial soils and bedrock are discussed in the following sections.

1.3.4.3.1 Surficial Geology

The native, surficial soils consist of 15-25 foot thick Pleistocene loess underlain by brownish-red gravelly clay, which is derived from the weathering degradation of the underlying Plattin Formation Limestone (limestone residuum soil), at the Site, to "terrace" and "alluvial" deposits in the wetland area. The United States Geological Survey (USGS) map of surficial geology depicts the Pleistocene loess within the vicinity of the Site, generally present on higher ground and "terrace" and "alluvial" deposits present in the valley areas, which supports this change in surficial geology.

The Pleistocene loess beneath the Site is classified as the Menfro silt, which is comprised of firm brown silty clay that is easily eroded, and characteristically develops on loess-covered ridge tops and hillsides of 5 to 9 percent slope. The Menfro silt extends to an average depth of 15 feet bgs in the area of the Site with clay content generally increasing with depth. The Menfro silt has a high water capacity, and moderate permeability and surface runoff.

The majority of the Property has been excavated to remediate PCB-impacted soil within the Menfro silt and limestone residuum, which lay at depths ranging from 0.5 and 27 feet bgs. The excavated soils were thermally treated and subsequently used to backfill the excavations. The thermally treated soil has a lower cohesive-bonding strength; therefore, this soil is more easily eroded. The treated soil also appears to be more permeable.

Surficial soils in the wetland area, to the southeast of the Site, include "terrace" and "alluvial" deposits consisting of rounded sands, silty sands with occasional discontinuous clay layers near wells MW-16A, MW-16B, MW-16C, MW-20A, MW-20B, MW-20C, MW-21A, MW-21B, and silty clay, clayey silt, sandy silt and silty sand near soil boreholes BH-19A through BH-19I. The alluvial deposits range in thickness from 9.5 feet, approximately 120 feet south of Wilson Road along Line ERT-MEW-13 (borehole BH-19I) to 146 feet near the Wetland Creek (wells MW-16C and MW-20C). The greater alluvium thickness noted within the Wetland area is caused by a depression feature, which possibly might be a localized low, within a buried former river channel, in the surface of the underlying Plattin Limestone.

Figure 1.5 shows the locations of geologic cross sections across the Site. **Figures 1.6, 1.7,** and **1.8** are the geologic cross-sections highlighting the geological sequence from the Site to the down gradient Wetland area, including the potential alluvial channel.

1.3.4.3.2 Bedrock Geology

The bedrock is encountered at depths varying between 21 feet and 65 feet bgs beneath the Site and to depths between 9.5 feet and 146 feet bgs beneath the Wetland area. The bedrock is composed of weathered, fractured and solution-enhanced massive limestone.

Bedrock structure was evaluated as part of the RI and included field fracture mapping (especially in nearby quarries), geoprobe investigations, geophysical ERT, seismic reflection and refraction assessments, and fracture network analysis using the FRACMAN computer model. The bedrock characterization studies were performed to evaluate the distribution and character of fractures and solution-enhanced discontinuities in the Plattin Formation Limestone, evaluate their relevance to local groundwater and transport of COPCs, assist in the identification of fracture zones, and to develop an improved understanding of the geologic structure at the Site and in the downgradient wetland area.

The bedrock characterization studies indicate that fracturing at the Site is dominated by two principal fracture sets. Both fracture sets are vertical (or near vertical) in dip, and the individual poles for each set are oriented at approximately 76° and 145°, respectively. Horizontal fractures and open bedding planes are common in the upper 15 feet of bedrock, but their frequency and spacing declines with depth. Fifty feet below the bedrock surface, horizontal fractures are rare, although this may represent a transport pathway of some significance. Fracturing appears to be more intense in the uppermost 31 feet of the bedrock with a fracture intensity of 0.09 ft^2/ft^3. Fracture intensity, which is related to fracture spacing and has been defined in Fracworks XP using the P_{32} parameter, represents the surface area of fractures to be found in a given volume of rock. In the deeper bedrock, the fracture intensity decreases by an order of magnitude, although the average fracture length (of vertical fractures) increases significantly. Fracture length through the bedrock appears to follow a lognormal distribution.

Based on field fracture mapping of five outcrop locations, including the Lone Star Quarry and East Missouri State Quarry, the bedrock underlying the Site and surrounding areas can be described as existing in the following three zones:

- **Upper weathered zone** – typically 50 feet thick. This zone is characterized by vertical fractures with large apertures, approximately 23 feet apart. These fractures have been enlarged by dissolution, especially at fracture intersections. Fractures with apertures in excess of 3 feet have been observed. The major fracture solution features in this zone are in filled with silty loess deposits. Horizontal bedding plane fracturing is common, especially in the uppermost 10 feet of the bedrock.
- **Intermediate zone** – approximately 115 feet thick. This zone is characterized by persistent vertical fractures spaced 100 to 150 feet apart, with some degree of dissolution-related opening. Fracture apertures are significantly narrower than those in the upper weathered zone and are characterized by varying degrees of calcite and other mineral deposition. Very few horizontal bedding fractures were observed, however this may represent a transport pathway of some significance.
- **Deeper zone** – greater than 260 feet thick. This zone is characterized by occasional discrete vertical fractures more than 150 feet apart. Fractures are narrow and frequently in filled with mineral deposits. Horizontal bedding fractures are rare in this zone; however this may represent a transport pathway of some significance.

General features of the bedrock structure interpreted from the results of ERT, seismic and geoprobe surveys are presented in **Figure 1.9. Figure 1.9** illustrates an alluvial-filled depression feature extending to at least as deep as 146 feet bgs is interpreted to exist in the area of monitoring well clusters MW-16, MW-17, MW-20 and MW-21. The deposits that infill this channel or alluvial feature and lie beneath the wetland area, are indicative of a fluvial environment and this feature may indicate a localized low-point within a former fluvial channel. The existing geologic and geophysical data collected in the wetland area can have several interpretations ranging from a closed geologic depression, to a segment of a larger buried channel feature which may, or may not be hydraulically connected to, and part of the Mississippi River Valley system.

Interpreted fracture trends, shown as dashed lines on **Figure 1.9**, vary from almost east-west to northwest-southeast, consistent with the fracture model developed from field data. The only fractures displayed are those for which evidence was observed on multiple geophysical profiles and/or inferred from increased geoprobe refusal depths. The location of a suspected fracture or joint feature was displayed along Line MEW-8 and a probable fracture or joint feature was also interpreted along Line MEW-9. The latter fracture zone is aligned with a similar feature as interpreted running through the Property well cluster and MW-13. The presence of a major vertical fracture zone within a depression in the bedrock structure was confirmed upon advancing monitoring wells MW-15A and MW-15B, based on rock core examination and depth of bedrock. Major vertical fractures features in the study area are often characterized by significant local depressions in the bedrock surface.

The fracture zone targeted at the location of wells MW-17A/B and indicated along Line ERT-MEW-11 was not found upon investigation. Similarly, the location of a fracture or joint feature displayed along Line MEW-13 was not confirmed upon advancing boreholes BH-19 A through I, which all encountered bedrock at <40 feet bgs.

1.3.5 HYDROGEOLOGY

The knowledge of groundwater hydrology is based on water levels measured in groundwater monitoring wells and surface water locations during quarterly groundwater monitoring events from 2000 to present and groundwater modeling activities. The majority of onsite wells are completed within the upper weathered bedrock zone with screened depths of less than 60 feet bgs. Monitoring wells MW-5 and MW-6 are completed in the loess, and monitoring wells MW-11 and MW-11A are completed within the intermediate and deep zones. Off-Property monitoring wells MW-16A, MW-16B, MW-16C, MW-17A, MW-18, MW-20A, MW-20B, MW-20C, MW-21A and MW-21B are completed within the alluvial deposits, and MW-15A, MW-15B and MW-17B are completed within the limestone.

1.3.5.1 Piezometry and Groundwater Flow

Analysis of groundwater level hydrographs from monitoring wells MW-3 and MW-11 indicate that groundwater within the upper weathered and intermediate zones are in hydraulic continuity. Monitoring well MW-11A, completed in the deep zone, has a different hydrograph response than wells MW-3 and MW-11, which are completed in the upper weathered and intermediate zones, respectively. This suggests that there is limited hydraulic continuity between the intermediate and deep zones.

The groundwater surface at the Property is approximately 40 feet bgs and often occurs within the limestone bedrock. The loess is generally unsaturated, with the exception of perched water (observed in well MW-6) and where the loess deposits occur within fractures in the bedrock below 40 feet bgs.

The majority of flow within the limestone bedrock is interpreted to occur within the fractures in the weathered and intermediate zones. The limestone within the deep zone is described as competent with few fractures. Any fractures that are present within this zone are mostly in filled with mineral deposits and, consequently, there is unlikely to be significant groundwater flow within this zone. The distribution of groundwater heads within the limestone is likely to be strongly influenced by the spatial distribution of fractures, which may give rise to difficulties in interpretation.

Groundwater monitoring from the Study Area indicates that the local hydraulic gradient is southeast toward the Wetland Creek, implying that groundwater flows in this direction. For the shallow alluvial deposits (<25 feet bgs, above a clay layer) the Wetland Creek acts as a groundwater discharge zone as described in the RI Report(Komex, 2005d) and groundwater modeling reports (Komex, 2003a and Komex, 2005e).

The depth to groundwater measured in November 2004 for shallow alluvium wells in the wetland area ranged between 0.47 feet and 3.86 feet bgs. **Figure 1.10** presents the potentiometric surface for wells screened in weathered bedrock (screened shallower than 100 feet bgs), loess, and shallow alluvium deposits (screened shallower than 25 feet bgs) as recorded in November 2004. **Figure 1.11** presents the potentiometric surface for wells screened in the deep alluvial deposits (screened between 50 feet and 150 feet bgs) as recorded in November 2004. Groundwater piezometry within the limestone is relatively complex and is likely influenced by the spatial distribution of fractures.

1.3.5.2 Hydraulic Conductivity

Hydraulic conductivity of the limestone and alluvium deposits has been estimated from slug testing and hydrograph analysis. Slug and packer tests conducted by EarthTech provide an estimate for upper weathered bedrock zone hydraulic conductivity between 2.6×10^{-3} and 0.26 feet/day (feet/d). Slug testing performed by Komex in 2003 gave estimates of bulk equivalent hydraulic conductivity between 0.03 and 2.0 feet/d for the limestone and hydraulic conductivity of 0.89 and 1.8 feet/d for the alluvial deposits beneath the wetlands (Komex, 2003a). The most recent slug testing by Komex (Komex, 2005e) provides estimates of hydraulic conductivity for wells MW-20A, MW-20B, MW-21A and MW-21B in the alluvial sediments in the wetlands ranging between 0.6 to 28.3 feet/d. Hydrograph analysis performed by Komex in 2003 provided higher estimates of bulk equivalent hydraulic conductivity for the limestone. Estimates using the hydrograph method vary between 10 and 158 feet/d for the upper weathered zone and 8 and 16 feet/d for the intermediate zone. It was concluded, based on data analyzed, that the hydrograph values are on the high end of likely estimates.

1.3.5.3 Demography and Land Use

The Site is located within the SW ¼ of the NW ¼ of Section 12, Township 30 North, Range 13 West, Cape Girardeau, Missouri within the corporate limits of the City of Cape Girardeau.

As of the census of 2000 there where 35,349 people, 14,380 households, and 8,297 families residing in the City of Cape Girardeau. Out of the 14,380 households, 25.7% have children under the age of 18 living with them, 43.8% are married couples living together, 10.9% have a female householder with no husband present, and 42.3% are non-families. 33.6% of all households are made up of individuals and 11.5% have someone living alone who is 65 years of age or older. The average household size is 2.24 and the average family size is 2.90.

In the City, the population is spread out with 20.5% under the age of 18, 18.4% from 18 to 24, 25.6% from age 25 to 44, 19.9% from age 45 to 64, and 15.5% who are 65 years of age or older. The median age is 34 years. For every 100 females, there are 89.5 males. For every 100 females age 18 and over, there are 86.9 males.

According to the U.S. Census Bureau, the City has a total area of 24.32 square miles (mi^2), of which 24.29 mi^2 of its land and 0.03 mi^2 of it is water. The total surface water area is 0.21%.

The Property is currently zoned for light industrial land use. The abutting properties and vicinity of the Property are primarily utilized for business/commercial/light industrial purposes. The adjacent properties occupy approximately 18 acres and include: the Diebold rental property located at the southwest corner of the Property; Cape Carpet, R&M Enterprises, and Paramount Liquor Company to the north and east; and Morrill Construction Company and Armor Mini Storage to the south. South Kingshighway borders the Property to the west.

The City of Cape Girardeau water supply is currently drawn from shallow wells near the Mississippi River and from the Mississippi River. Water Treatment Plant #1 is in the process of changing its water source from the Mississippi River to alluvial wells located on a sandbar along the river, north of town. Water Treatment Plant #2 has shallow wells on the river's floodplain south of the city where the water table is high. The nearest municipal water supply well (Well #3) relative to the Property is approximately 2 miles southwest of the Property.

1.4 NATURE AND EXTENT OF COPCS

The following sections briefly describe the onsite source areas and distribution of COPCs in groundwater at the Site. The source areas on the Site are depicted in **Figure 1.12** and the distribution of COPCs in groundwater from the Fourth Quarterly 2004 sampling event is shown on **Figure 1.13**.

COPCs considered in the BHHRA (Komex 2005f), are defined as compounds that had concentrations in excess of the Region IV Preliminary Remediation Goal (PRG) for tap water (screening level) and non-carcinogenic compounds that had concentrations in excess of the screening levels when multiplied by 0.1 (to account for potential additive effects). In addition, compounds, which were analyzed for and not detected, but had method detection limits (MDLs) in excess of the respective screening levels, were also included as COPCs. There is considerable uncertainty whether these undetected compounds actually impact groundwater at the Site.

A full list of COPCs and a detailed discussion of the methodology used to develop COPCs is presented in the BHHRA (Komex 2005f).

1.4.1 SOURCE AREAS

The main source of COPC impacted groundwater at the Site appears to be related to the releases of dielectric fluid associated with onsite drum storage and past recycling operations. Prior to the 1999 soil remedial action, a majority of the surface soils sampled contained PCBs with sporadic detections of volatile organic compounds (VOCs) including methylene chloride, trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA) and chlorobenzene. Approximately 75 percent of the surface soils (approximately 295,000 square feet or 6.77 acres) on the Property and surrounding areas were found to be impacted with PCBs at concentrations of 10 ppm or greater (USEPA, 1990). PCBs adsorbed onto near-surface soils were transported onto surrounding properties via storm water runoff. Therefore, PCB contamination was located primarily along drainage pathways with concentrations decreasing with increasing distance from the Property.

Results of previous investigations and RI sampling indicated that PCB–impacted soils on the Property were found at depth primarily in two areas, the debris burial area (Area 1) and the transformer storage area (Area 2), as shown on **Figure 1.12**. Area 1 is a rectangular-shaped area, approximately 180 feet by 82 feet, located on the southeast side of the Property between MW-14 and MW-12 and centered on the MW-3/MW-5/MW-11/MW-11A well cluster. A former ditch running northwest to southeast just to the east of the well cluster is believed to be the primary source of PCB contamination in Area 1. Area 2, which has historically been used as a transformer storage area, is an elongated-shaped area located at the center of the Property between wells MW-4 and MW-10. Area 2 is generally defined by detections of TCE and tetrachloroethene (PCE) in monitoring wells MW-4 and MW-10. A maximum concentration of 17 ug/L was detected in well MW-10 (March 1990 and January 1991), while a concentration of 8.2 ug/L was detected at well MW-11 during the November 2004 sampling event. The concentrations of PCE and TCE in soil detected in this localized area are low (Komex, 2005d).

COPCs detected in groundwater beneath the Site and surrounding areas consists primarily of PCBs, VOCs and SVOCs related to the former soil source areas. Inorganic compounds were investigated during the initial RI work in the late 1980s and early 1990s and it was determined that the inorganics concentrations at the Site did not indicate the presence of contamination associated with the operations of MEW (EarthTech 1990, USEPA 1990 ROD). Based on this evaluation and at the direction of the agency, inorganic compounds are not listed as COPCs. The distribution of PCBs, VOCs and SVOCs detected above laboratory reporting limits (RLs) and MCLs, based on groundwater monitoring conducted in November 2004, is presented in **Figure 1.13**.

1.4.2 PCBS

Historically, PCBs (Aroclor 1260) have been detected in unfiltered samples collected from six monitoring wells. These wells include: well MW-3 (at up to 4.7 ug/L, and below the method detection limit in November 2004); well MW-5 (at up to 110 ug/L, 2.9 ug/L in November 2004); well MW-7 (only once at a concentration of 0.35J); well MW-11 (at up to 110 ug/L, below the laboratory reporting limit in November 2004); well MW-11A (at up to 55 ug/L, and below the method detection limit in November 2004); and well MW-12 (at up to 8.3 ug/L, and below the method detection limit in November 2004). PCB results for filtered samples have only been reported for samples collected from well MW-11 over two sampling events (June and September, 2000) at concentrations ranging from 2.0 to 4.5 ug/L, after which no result was greater than the laboratory method detection limit. PCBs have not been detected down gradient of the MEW Property since October 2003.

The PCB testing suite included six PCBs, of which only Aroclor-1260 was detected above the MDL, as discussed above. The other five PCBs: Aroclor-1254, Aroclor-1221, Aroclor-1232, Aroclor-1248 and Aroclor-1242 were not detected above their respective MDLs, however, MDLs for these PCBs exceeded the respective screening level and as such, these PCBs were considered as COPCs in the BHHRA (Komex, 2005f).

PCBs tend to strongly adsorb onto particles of clay and organic material, precluding significant migration in the dissolved phase. Typically, PCBs detected in groundwater have been associated with the sediment suspended within the groundwater column, possibly present as sediment at the bottom of each well (and filter pack), and re-suspended during groundwater monitoring activities. This has been confirmed by sampling sediments collected at the bottom of wells MW-5, MW-11, and MW-11A on from September 27- to 29, 2000. All three sediment samples had detected concentrations of PCBs: 5,500 ug/kg in well MW-5; 1,700 ug/kg in well MW-11; and 49,000 ug/kg in well MW-11A. Additionally, these monitoring wells were kept intact during thermal treatment activities. Therefore, some remaining impacted material might reside in close proximity to each of these wells.

Movement of sediment particles from the shallow zone, vertically downward under natural hydraulic gradient, is considered relatively unlikely. This is because sediment particles with adsorbed PCBs would have to migrate their way through the silty-clay sediments, which infill the large vertical fractures in the weathered upper bedrock zone. This winnowing process would require large volumes of percolating water and relatively high flow velocities to mobilize the particles. While it is possible that this occurs in large fractures or weathered zones, it is highly unlikely to occur in the zone represented by well MW-11

The volume of water required and high flow velocities required to mobilize the PCBs, combined with isotopic evidence (low tritium units [<0.6 TU]) for the presence of older water at depth, point toward the emplacement of COPC at depth via previous drilling practices, especially during lost-circulation events, aggressive pumping during well development, and subsequent aquifer testing (as documented in the Supplemental Hydrogeologic Investigation Report – Earth Tech, 1991). Lost-circulation problems during the Earth Tech (1991) drilling program resulted in significant accumulations of drill-cut sediments in the bottom of boreholes. It is possible that sediment particles with attached PCBs found in voids in well MW-11 were introduced through the drilling and aquifer testing processes in the early 1990s.

Based on the declining trend in PCB concentrations (Komex, 2002b) and the fact that PCBs tend to strongly adsorb onto particles of clay and organic material, it is unlikely that groundwater is a significant dissolved phase transport medium for PCBs (Komex, 2005d).

1.4.3 VOCS AND SVOCS

The main organic compounds detected in groundwater include: chlorobenzene, 1,2-dichlorobenzene (1,2-DCB), 1,3-dichlorobenzene (1,3-DCB), 1,4-dichlorobenzene (1,4-DCB), 1,2,4-trichlorobenzene (1,2,4-TCB), 1,1,1-TCA, TCE, PCE, 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCE) and benzene.

Chlorobenzene, 1,2-DCB, 1,3-DCB, 1,4-DCB, 1,2,4-TCB and benzene are all potential components of dielectric fluid, which was recycled from transformers at the Property. Both 1,4-DCB and chlorobenzene are also potential "daughter products" of breakdown of 1,2,4-TCB. Furthermore, 1,1,-DCA and 1,1,-DCE can be derived from the breakdown of 1,1,1-TCA, while 1,2-DCE and 1,1,-DCE can be derived from the breakdown of PCE and TCE. Degradation of chlorinated solvent compounds can occur through both abiotic and biotic mechanisms. Chlorinated solvents may biodegrade both aerobically and anaerobically.

VOCs found above the method detection limits in groundwater samples collected during the November 2004 monitoring event are presented on **Figure 1.13**. In addition, concentrations above the MCLs, in November 2004 include:

- chlorobenzene;
- benzene;
- TCE; and,
- unfiltered PCBs - Aroclor 1260.

Specific organic COPC are discussed further below.

Of the VOCs detected in groundwater, chlorobenzene has been detected at the highest concentrations and in the most samples. The highest concentration of chlorobenzene was detected in monitoring well MW-12 at a concentration of 3,200 micrograms per liter (ug/L) in November 2004. The previous maximum concentration was 3000 ug/L in December 2002, which had subsequently decreased to 1,500 ug/L in May 2004. Chlorobenzene has also historically been detected in monitoring wells MW-3 and MW-5, located up gradient of well MW-12, at maximum concentrations of 1,600 ug/L and 130 ug/L respectively (390 ug/L and 14 ug/L in November 2004). Chlorobenzene has also been detected on a regular basis in monitoring wells MW-4 (at up to 42 ug/L), MW-11 (at up to 68 ug/L) and MW-14 (at up to 8.9 ug/L). Down gradient of the Property, chlorobenzene has only been detected above the laboratory reporting limit in well MW-7 (at up to 9.8 ug/L). Chlorobenzene was detected at a J qualified concentration of 2.9J ug/L for a duplicate sample collected from well MW-16C in November 2004. There was no detection above the method detection limit for chlorobenzene in the primary sample collected during the November sampling event from well MW-16C.

Benzene was detected in monitoring well MW-12 (at up to 83 ug/L, generally increasing from 26 ug/L since December 2002) and well MW-3 (at up to 17 ug/L) on the Property. Benzene has not been detected above the laboratory reporting limit in samples from groundwater monitoring wells down gradient of the Property. An estimated J qualified detection of 1.7J ug/L was reported for a sample from well MW-16B for the November 2004 groundwater sampling event.

TCE has been detected in monitoring wells MW-4 (at up to 5.2 ug/L), MW-10 (at up to 17[19?] ug/L), MW-11 (at up to 8.9 ug/L) and in WSW-1 (at up to 4.5J ug/L [below reporting limit]) on the Property. There is historical reference to a maximum on-site detection of TCE at a concentration of 19 ug/L; however the well at which this detection occurred is uncertain (USEPA, 1990).

TCE has been detected down gradient of the Property in monitoring wells MW-7, MW-16B and MW-16C at a concentration above the laboratory reporting limit. The November, 2004 sampling event detected an estimated TCE concentration of 2.0J ug/L for well MW-15A. Monitoring well MW-7 only had one detection of TCE at a concentration of 9.0 ug/L in March 1990, immediately after well installation, and samples from this well have been below detectable levels since. Maximum TCE concentrations of 9.9 ug/L and 9.2 ug/L have been detected in samples from monitoring wells MW-16B and MW-16C, respectively. These wells are located in the wetland area, screened in alluvial deposits. Estimated TCE values of 2.0J and 1.4J ug/L were observed in groundwater samples from wells MW-15A and MW-14 respectively during the November 2004 sampling event. In November 2004, TCE was detected at concentrations above the MCL (8.4 ug/L, 7.4 ug/L and 8.2 ug/L for wells MW-16B and MW-16C and MW-11, respectively).

1.5 COPC FATE AND TRANSPORT

The following is a summary of the COPC fate and transport findings presented in the RI Report (Komex, 2005d), Groundwater Modeling Report (Komex, 2003a) and Groundwater Flow and Transport Supplemental Modeling Letter Report (Komex, 2005e).

The principal mechanism for transport of COPCs is in the dissolved phase. Generally, the upland ridge upon which the Property is situated acts as a local-scale groundwater flow system. Recharge infiltrates into the subsurface, percolating downward through the overburden, and in some cases, the upper weathered bedrock to the groundwater table. The groundwater flow direction is determined primarily by the dominant hydraulic gradient. Near the Property, the hydraulic gradient is dominantly horizontal, to the southeast toward the wetland and creek, which lie in the shallow valley to the southeast of the Site. On the upland ridge, there is also a smaller vertically downward component of flow. At the Site, the surficial loess deposits, which overlie bedrock, are largely unsaturated, and the groundwater surface exists within the upper weathered and fractured bedrock. Thus, at the Site, the predominant groundwater flow occurs within the fractured, weathered bedrock.

Groundwater flow within the bedrock in the study area is fracture-dominated. Fractures, and fractures which have been solution-enhanced to create "voids", are the main contributors to bedrock permeability. Matrix permeability is very low in comparison, and so groundwater flow occurs most readily through these fractures. As described in **Section 1.3.4.3.2**, rock fracturing is most intense in the upper few feet of bedrock, and fracture size, length, aperture and frequency decrease sharply with depth. Below 150 feet, fracturing is relatively rare, with vertical fracturing predominating. In the more competent fractured bedrock, almost all of the flow occurs only within discrete fractures themselves. Evidence of the occlusion of some of these fractures by mineralization was observed.

Major vertical fractures appear to have a major influence on groundwater flow and COPC transport. The two identified major vertical fracture sets in the study area trend approximately NE-SW and NW-SE. The hydraulic gradient at the Site is oblique to these main fracture orientations, which gives a highly complex conceptual COPC transport pattern, resulting from the components of hydraulic gradient which apply in each of the fracture sets. The combination of the hydraulic gradient and an anisotropic media can result in a myriad of hypothetical tortuous flow paths as described in the fracture flow and transport modeling (Komex, 2003a). Therefore, although the general pattern of groundwater flow from the Site is known to occur within weathered bedrock and discretely fractured bedrock, the precise pathways of flow are complex, and are, in practical terms, not possible to fully or precisely define. This is clearly shown by the distribution of COPC in the study area.

Given the concentrations of particular COPCs on the Property boundary (for instance, chlorobenzene in MW-12), it is surmised and predicted by equivalent porous medium (EPM) groundwater fate and transport modeling that chlorobenzene should appear in fractured bedrock monitoring wells downgradient of the Site. Despite attempts to place monitoring wells down-gradient in the bedrock to find the chlorobenzene, none has been actually detected. While the prediction of some COPCs in discretely fractured bedrock down-gradient of the Site can be made with confidence, it is technically impractical, even with significantly greater expenditure, to locate the exact fractures where COPCs exist due to the extremely complex fracture network, and the complex forces governing COPC transport and behavior within those fractures. It is equally difficult to place monitoring wells precisely enough within such fractures to ensure representative detection of COPCs.

After migrating through the bedrock fracture network, on an indeterminate pathway, which has only been conceptually approximated using a stochastically-generated discrete fracture network model and particle flow through that network (Komex, 2005e), COPCs are predicted to discharge along the interface between the bedrock and the alluvial depression to the southeast.

Given these conditions, the EPM model developed for the Site is the only practical way of representing overall groundwater and COPC behavior. COPCs are made to discharge into the alluvial deposits at one specific point, representing a single idealized major fracture, which carries COPCs from the source areas on the Property directly to the alluvium. This provides a worst-case scenario of COPC transport, delivering concentrated COPCs quickly and directly to the alluvial deposits. However, as clearly shown in the discrete fracture modeling, it is far more likely and realistic that COPCs are reaching the alluvium through many smaller fractures, at discrete points along a broad front of the alluvium-bedrock interface (perhaps as much as 1,000 feet wide), but much more slowly than predicted in the highly conservative (worst-case) EPM model, and at much lower concentrations and mass-fluxes. Thus, the overall effect is that COPC concentrations in the bedrock and the alluvium are likely to be much lower, at any given point in space, than predicted by the EPM model. This is exactly the situation observed in the field data. COPC concentrations measured in offsite wells are in all cases lower or significantly lower (below RL) than model predictions. This reflects the complexity of the bedrock flow pathways and our inherent, technologically-limited ability to characterize the bedrock flow and transport with any degree of accuracy. Although the EPM model can reasonably predict COPC concentrations in a simulated fracture and model results are valid for scales of evaluation that are likely to include one or more fractures, the exact occurrence, location and geometry of fractures in the field are not known. Therefore, model results can be used to assess worst-case risk to hypothetical receptors (by wells modeled as being installed in simulated fractures); however, the results can not be used at the scale necessary to precisely locate wells for either remediation or water supply purposes.

After groundwater discharges to the alluvium, most often at depth, it is subjected to a change in hydraulic properties and flow regime. Groundwater flow to the southeast in the alluvium is influenced by the interaction of the wetland and the creek with the shallow groundwater flow system. Generally, there appears to be an upward and eastwards flow towards the creek from the Site in the alluvium, as the wetland creek acts as a base of drainage for the local-scale groundwater flow system. Conversely, from the upland ridge to the south of the creek, groundwater flow in the alluvium is towards the north and east towards the creek. In addition, groundwater flow within the alluvium is locally influenced by heterogeneities and a potential partial confining layer of unknown extent has been observed in at least at one location (near the MW-16 well cluster).

1.6 BASELINE HUMAN HEALTH RISK ASSESSMENT

This section presents a summary of the results of the BHHRA (Komex, 2005f), which assessed the risks posed to human health by impacted groundwater beneath the Site and surrounding areas. This section should be read in conjunction with the RI and BHHRA reports (Komex, 2005d and Komex, 2005f).

A Conceptual Exposure Model (CEM) was developed for the Site based on the following future land uses:

- Commercial/industrial use at the Property. A deed restriction will be applied to the Property to ensure that groundwater beneath the Property cannot be used for water supply.
- Residential use on wetland area. City zoning for this area is light industrial/commercial. The assumption of residential land use is therefore considered conservative.

The CEM identified the following potentially complete exposure pathways that should be quantified:

- Exposure to an adult worker at the Site from the inhalation of COPC vapors that have migrated from the subsurface through the floor into the building;
- Exposure to an off-Site construction worker from direct contact with shallow groundwater in the wetland area; and
- Exposure to an off-Site resident from: (1) inhalation of COPC vapors that have migrated from the subsurface through the floor into the building; (2) ingestion/dermal contact of COPC in groundwater used for water supply; (3) inhalation of COPC arising from use of groundwater; and (4) ingestion and dermal contact with COPC in surface water during recreational use of the creek. Exposure to an off-Site resident not using groundwater at the Site for water supply was also considered.
- Exposure to possible trespassers from recreational use of the creek (dermal contact and incidental ingestion).

COPC were identified by comparison of maximum concentrations detected in groundwater with risk screening values. The USEPA Region 9 Preliminary Remediation Goals (PRGs) for the tap water pathway have been used to derive these screening values. There were 52 compounds selected as COPC, of which 48 have been quantitatively evaluated in this BHHRA. Thirty one of the organic COPC have never been detected in groundwater at the Site but have been selected as COPC because the maximum method detection limit (MDL) for these analytes exceeds the applied screening toxicity values. Four additional non-detected chemicals were retained as COPC but were not evaluated quantitatively in this risk assessment due to the absence of available toxicity data.

Inorganic compounds were investigated during the initial RI work in the late 1980 and early 1990s and it was determined that the inorganic concentrations at the Site did not indicate the presence of contamination associated with the operations of MEW (EarthTech 1990, USEPA 1990 Record of Decision [ROD]). Based on this evaluation and at the direction of the agency, inorganic compounds are not listed as COPC.

Fate and transport modeling was used to predict point of exposure (POE) concentrations for the identified receptors. Two types of modeling have been conducted: (1) groundwater modeling to predict reasonable maximum exposure (RME) concentrations of organic COPC that could occur in groundwater off Site; and (2) vapor modeling to predict RME concentrations of organic COPC that could occur in indoor air as a result of impacted groundwater beneath a building.

Exposure equations and factors were obtained from the USEPA Risk Assessment Guidance for Superfund (RAGS) for quantifying exposure for each of the pathways identified in the CEM. Parameter values were selected to ensure that the RME was quantified. Parameter values were also collated for central tendency exposure (CTE).

Toxicological data were obtained from the appropriate sources following USEPA's hierarchy. For the purposes of this risk assessment, 37 compounds were considered carcinogenic. Reference doses and cancer slope factors were obtained for these compounds, where available. Fifteen compounds were treated as non-carcinogens. Reference doses were obtained for these compounds, where available. A range of cancer slope factors was identified for trichloroethene (TCE). Three slope factors representing this range have been used for characterizing risks from TCE.

The results of the exposure assessment have been combined with the toxicological data to allow the risks associated with impacted groundwater below and extending from the Property to be evaluated. A conservative approach has been adopted for both the exposure assessment and selection of toxicological parameters. The calculated RME risk factors for organic COPC using these conservative assumptions are presented below:

Receptor	Total Hazard Index (HI) For Organic COPC	Incremental Lifetime Cancer Risk (ILCR) For Organic COPC
Adult worker on MEW Property	0.1	1×10^{-5} to 6×10^{-6}
Adult off-Site construction worker in wetland area	2	5×10^{-7} to 4×10^{-7}
Resident (child and/or adult) on wetland area using impacted groundwater for water supply (Hypothetical Well D)	124	1×10^{-2}
Resident (child and/or adult) on wetland area with municipal water supply (Hypothetical Well C)	0.06	2×10^{-6} to 3×10^{-7}
Trespasser	0.003	3×10^{-8}

The calculated RME HI for organic COPC for the adult on-Site worker is 0.1. The RME ILCR for organic COPC for an adult worker ranges from 1×10^{-5} to 6×10^{-6}, depending on the TCE slope factor used. This ILCR is based on a 25-year exposure duration averaged over a 70-year life span.

The calculated RME HI for organic COPC for the adult off-Site construction worker in the wetland area is 2. The RME ILCR for organic COPC for an adult off-Site construction worker ranges from 5×10^{-7} to 4×10^{-7}, depending on the TCE slope factor used. This ILCR is based on a 1-year exposure duration averaged over a 70-year life span.

The EPM has shown that elevated concentrations of organic COPC could exist within the limestone and alluvial deposits beneath the wetland area. A range of risks has been calculated for a future resident using three hypothetical water supply wells located in the wetland area. The highest risk has been predicted for the residential receptor when the drinking water supply well is located within the plume of impacted groundwater. A maximum RME HI of 124 and an ILCR of 1×10^{-2} have been predicted for organic COPC for this scenario using the worst case concentrations predicted by the groundwater model. The ILCR values for the residential receptor are based on a 30-year exposure duration, including 6 years as a child and 24 years as an adult, averaged over a 70-year life span.

The maximum calculated RME HI for organic COPC for a resident that does not use groundwater for water supply or uses groundwater not impacted by organic COPC is 0.06. The calculated ILCR for organic COPC for this scenario is 2×10^{-6} and 3×10^{-7}, depending on the slope factor used.

The calculated RME HI for organic COPC for a trespasser from recreational use of the creek (dermal contact and incidental ingestion) is 0.003. The calculated maximum ILCR for this scenario is 3×10^{-8}. The ILCR values for the trespasser are based on an exposure duration as defined for the off-Site resident.

Based on the USEPA's acceptable risk range of 1.0×10^{-4} to 1.0×10^{-6}, and an acceptable HI of 1, the following conclusions are drawn from the risk assessment:

- Indoor vapor intrusion from impacted groundwater beneath the Property was assessed as the only potentially complete pathway for future on-Site workers. Risk quantification for organic COPC has shown no significant risk to future on-Site workers from this pathway.
- Dermal contact with and incidental ingestion of impacted shallow groundwater were assessed as the only potentially complete pathways for future off-Site construction workers. Risk quantification for organic COPC showed no significant cancer risk to future off-Site workers from this pathway. However, the assessment showed that there could be a significant non-cancer risk from organic COPC to future off-Site workers from this pathway
- The use of impacted groundwater for water supply, indoor vapor intrusion from impacted groundwater and recreational use of the creek (dermal contact and incidental ingestion) were assessed as the only potentially complete pathways for future off-Site residents. Risk quantification for organic COPC showed no significant risk to future off-Site residents from indoor vapor intrusion and recreational use of the creek. The assessment showed that there could be a significant risk from organic COPC to future residents living in the wetland area if they were to use impacted groundwater as their water supply.
- Risk quantification for organic COPC showed no significant risk to future residents living in the wetland area if they use an alternative water supply (*i.e.*, municipal water supply).
- Recreational use of the creek (dermal contact and incidental ingestion) was assessed as the only complete pathway for trespassers on the wetland area. This pathway was quantified as part of the residential scenario and showed no significant risk from organic COPC. It has therefore been concluded that there is no significant risk from organic COPC to trespassers from recreational use of the creek.

In summary, the results of the risk assessment have demonstrated that the risk to adult workers at the MEW Property is unlikely to be significant. This is based on the assumption that a restriction is applied to the Property to prevent the usage of groundwater beneath it. Groundwater fate and transport modeling has indicated that the groundwater plume containing COPC could extend off Site to the southeast of the MEW Property beneath the wetland area. Exact prediction of the plume extent is not possible due to the uncertainties inherent in modeling COPC migration in fractured media. The risk assessment has shown that use of the potentially impacted groundwater beneath the wetland area could present a significant risk to receptors. It has also been demonstrated that there could be a significant risk from organic COPC to future off-Site construction workers in the wetland area.

2 IDENTIFICATION/DEVELOPMENT OF ARARS AND TBCS, RAOS AND GENERAL RESPONSE ACTIONS

This section presents the factors, which will be considered in assessing the need for remediation and identifies possible GRAs as well as Site RAOs, which are based upon the identified COCs and TCLs. In addition, volumes of impacted groundwater are estimated in this Section.

2.1 IDENTIFICATION AND COMPILATION OF ARARS AND TBCS

ARARs are environmental or public health requirements that are promulgated by the State or Federal Government and are determined to be legally applicable or relevant and appropriate to the chemicals/COCs, remedial activities, or other actions/circumstances at a CERCLA site NCP Section 300.5 (NCP, 1995). CERCLA mandates compliance with applicable requirements, and requirements deemed relevant and appropriate by the USEPA for onsite activities, unless a waiver can be justified. Substantive requirements need to be fulfilled for onsite activities, but administrative requirements (e.g., Federal, State and local permits; reporting requirements, etc.) do not need to be attained. Offsite activities related to Superfund responses only need to comply with applicable requirements, but both substantive and administrative compliance are necessary. The two types of ARARs, "applicable" and "relevant and appropriate" requirements are defined below.

<u>Applicable Requirements:</u> The NCP (NCP, 1995) defines "applicable" requirements as "those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site." The requirement is applicable if the jurisdictional prerequisites of the standard show a direct correspondence when objectively compared to the conditions at the site. An applicable federal requirement is an ARAR. An applicable State requirement is an ARAR only if it is more stringent than federal ARARs. If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate.

<u>Relevant and Appropriate Requirements:</u> The NCP (NCP, 1995) defines "relevant and appropriate" requirements as "those clean-up standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address

problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site." A requirement must be determined to be both relevant and appropriate in order to be considered an ARAR.

The criteria for determining relevance and appropriateness are listed in 40 C.F.R. §300.400(g)(2) and include the following:

- The purpose of the requirement and the purpose of the CERCLA action;
- The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site;
- The substances regulated by the requirement and the substances found at the CERCLA site;
- The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site;
- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site;
- The type of place regulated and the type of place affected by the release or CERCLA action;
- The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action; and
- Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the CERCLA site.

According to CERCLA ARARs guidance (USEPA, 1988b), a requirement may be "applicable" or "relevant and appropriate," but not both. Identification of ARARs must be done on a site-specific basis and involve a two-part analysis: First, a determination whether a given requirement is applicable; then, if it's not applicable; A determination whether it is nevertheless both relevant and appropriate. It is important to explain that some regulations may be applicable or, if not applicable, may still be relevant and appropriate. When the analysis determines that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable (USEPA, 1988b).

Non-promulgated advisories or guidance issued by federal or state governments are not legally binding and do not have the status of ARARs. Such requirements may, however, be useful, and are "to be considered" (TBC). TBC (40 C.F.R. § 300.400[g][3]) requirements complement ARARs but do not override them. They are useful for guiding decisions regarding cleanup levels or methodologies when regulatory standards are not available.

Pursuant to USEPA guidance (USEPA, 1988b), ARARs are generally divided into three categories: chemical-specific, location-specific, and action-specific requirements. This classification was developed to aid in the identification of ARARs; some ARARs do not fall precisely into one group or another. These categories are described below, and general examples of ARARs and TBCs potentially applicable to the Site are discussed.

2.1.1 POTENTIAL CHEMICAL-SPECIFIC ARARS AND TBCS

Chemical-specific ARARs and TBCs are typically health-based or risk-based numerical values or methodologies applied to site-specific conditions that result in the establishment of TCLs. In general, chemical-specific requirements are set for a single chemical compound or a closely-related group of chemical compounds. Typically, these standards do not account for the potential effects of multiple COCs. The identified chemical specific ARARs and TBCs, and their consideration in the FS are summarized in **Appendix B, Table B.1**.

Examples of chemical-specific ARARs include the Federal Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs), MDNR MCLs (State MCLs), MDNR Water Quality Standards (WQS), and MDNE Groundwater Target Concentrations (GTARCs). Examples of chemical-specific TBCs include USEPA health advisories, reference doses, and cancer slope factors. Chemical-specific ARARs and TBCs are employed to establish TCLs.

2.1.2 POTENTIAL LOCATION-SPECIFIC ARARS AND TBCS

Location-specific ARARs place limitations or standards on the types of activities, which can be performed, or the concentrations of COCs allowed, based on location in specific areas. The identified location-specific ARARs and TBCs, and their consideration in the FS are summarized in **Appendix B, Table B.2**. General examples of location-specific ARARs, which may apply to the Site, are presented below.

Location-specific ARARs include regulations, such as Executive Order 11990 (Protection of Wetlands), Executive Order 11988 (Floodplain Management), The Fish and Wildlife Coordination Act, National and State Endangered Species Regulations, and The National Historical Preservation Act, which are intended to minimize or prevent harm to sensitive areas such as wetlands, floodplains, fragile ecosystems, areas of endangered species, and historic features. Other location-specific ARARs are intended to restrict activities that are potentially harmful because of where they take place. For example, Resource Conservation and Recovery Act (RCRA) and State Hazardous and Solid Waste Rules/Policy restrict the placement of facilities in geologically unstable areas.

2.1.3 POTENTIAL ACTION-SPECIFIC ARARS AND TBCS

Action-specific ARARs typically are activity-based or technology-based regulations or restrictions on remedial actions or other activities related to mitigation of hazardous wastes. These action-specific requirements do not dictate what the selected remedial alternatives are; however, they do regulate the way in which an alternative is implemented. General examples of action-specific ARARs that may apply to the Site are presented below. The identified action-specific ARARs and TBCs, and their consideration in the FS are summarized in **Appendix B, Table B.3.**

Action-specific ARARs include State and Federal regulations related to the RCRA, Clean Water Act (CWA) and Clean Air Act (CAA). RCRA regulations include design and operating standards for facilities that treat, store or dispose of hazardous wastes; groundwater monitoring requirements; and closure standards for treatment, storage and disposal facilities. CWA regulates the discharge of pollutants to surface waters, including direct discharges to surface water (e.g., of treated groundwater) and indirect discharges through publicly owned treatment works (POTW). CAA regulates air emissions including those from hazardous waste treatment/remediation operations.

2.1.4 POLICY CONSIDERATIONS

As part of the development and assessment of remedial alternatives, additional policy and guidance documents from the USEPA were reviewed and taken into account as appropriate. Typically, these documents were not considered ARARs or TBCs for the Site.

The USEPA guidance documents Land Use in the CERCLA Remedy Selection Process (USEPA, 1995) and The Role of Cost in the Superfund Remedy Selection Process (USEPA, 1996a) were considered during the development and evaluation of remedial alternatives.

The USEPA guidance document for conducting remedial investigations (USEPA, 1988a) and Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites (USEPA, 1996b) were considered during the development and evaluation of management of migration alternatives to address impacted groundwater.

2.1.5 ARAR WAIVER

In some circumstances, ARARs can be waived. The six general waivers stated in CERCLA §121(d) are paraphrased below:

1. The remedial action is an interim measure and is part of a final remedy that will attain the waived ARAR upon completion.

2. Compliance with ARARs will result in greater risk to human health and the environment than other options that do not comply with ARARs.

3. Compliance with ARARs is technically impracticable from an engineering perspective.

4. The remedial action will not meet ARARs, but will attain an equivalent standard of performance through use of another method of approach.

5. The state has not consistently applied a state ARAR or demonstrated the intent to apply the ARAR to similar remedial action sites.

6. Superfund money spent at a site will not provide a balance between the need to protect human health and the environment and the availability of Superfund money for response actions at other facilities.

If appropriate, the revised ROD will document the justification of any waived ARARs.

2.2 REMEDIAL ACTION OBJECTIVES

Remedial action expectations for contaminated groundwater are stated in the NCP, as follows: *"EPA expects to return usable ground waters to their beneficial uses whenever practicable, within a time frame that is reasonable given the particular circumstances of the site. When restoration of ground water to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated ground water and evaluate further risk reductions."* These program expectations have been used to define the following general overall goals for remedial actions, which are typically applicable for all sites with contaminated groundwater:

- Prevent exposure to contaminated groundwater, above acceptable risk levels;
- Prevent or minimize further migration of the contaminant plume;
- Prevent or minimize further migration of COCs from source materials to ground water; and
- Return groundwater to their expected beneficial uses whenever practicable.

These goals are listed in the sequence in which they shall be addressed and used to develop the RAOs for the Site.

RAOs consist of medium-specific, quantitative goals that define the extent of cleanup required to protect human health and the environment, and to comply with ARARs. RAOs identify the environmental media and COCs, exposure pathways and potential receptors and TCLs for each exposure pathway/receptor. The RAOs are used to develop a range of remedial alternatives intended to reduce receptor exposure to contaminated media.

The three principal aspects of RAO development are presented below and include COC identification, TCL development, and RAO formulation.

2.2.1 COC IDENTIFICATION

COCs were identified based on the results of the BHHRA, and are defined as COPCs that significantly contribute to a pathway in a use scenario for a receptor (e.g. current adult construction worker, future child and adult worker, etc.) that either exceeds a State or Federal chemical-specific ARAR or exceeds a 10^{-6} cumulative site cancer risk or non-carcinogenic HI of 1. COPCs with individual carcinogenic risk contribution less than 10^{-6} and non-carcinogenic hazard quotient (HQ) less than 0.1 are not considered significant contributors to risk, therefore, were not included as COCs. A list of identified COCs is presented in **Table 2.1**.

2.2.2 GROUNDWATER TARGET CLEANUP LEVELS

Groundwater TCLs were developed for the Site to be protective of human health and to comply with chemical-specific ARARs. In addition, the TCLs developed for the various COCs were compared against practically attainable analytical RLs to ensure compliance. The proposed groundwater TCLs for the Site remedial action are summarized in **Table 2.1**.

TCLs were chosen to be equivalent to MCLs (for COCs which have established MCLs) because they are legally enforceable standards for drinking water and the calculated site-specific risk-based levels for protection of human health (derived from the cumulative risk calculation [Komex, 2005f)]) are lower than the respective practically attainable RLs. In the case of COCs with MDNR MCLs (State MCLs), which are more restrictive than MCLs, the State MCLs were identified as the TCLs. In the case of COCs without a promulgated MCL/State MCL, the TCL was chosen to be equivalent to WQS or GTARC, whichever is greatest. The proposed TCLs are presented in **Table 2.1**. The considered TCL categories are briefly described below:

<u>Protection of Human Health:</u> TCLs based on potential risks associated with human exposure to Site groundwater were estimated for the potential future offsite resident RME scenario, assuming a cumulative (i.e., all identified COPCs) carcinogenic risk of 1 x 10^{-6} and a cumulative HI of 1.0 (**Appendix E**).

Chemical-specific ARARs: ARARs considered in developing TCLs are MCLs and State MCLs, which are established drinking water standards for public water supply systems. State MCLs are employed to develop TCLs where they are stricter than Federal standards. For the given COCs, the numerical values for MCLs and State MCLs are the same. In cases where MCLs and State MCLs are absent for a given COC, MDNR WQS or GTARCs shall be employed to develop TCLs for groundwater.

Analytical Detection Limits: Laboratory MDLs and RLs were considered in the development of TCLs. Given the uncertainty regarding the concentration of COCs detected below the RL it is considered impractical to set a clean up criteria that cannot be quantified to an acceptable confidence level. Furthermore, the restoration of an aquifer to levels below MDLs is probably unattainable by current remedial technologies in a reasonable time frame. Therefore, TCLs selected for the Site will not be set below practically attainable RLs.

2.2.3 REMEDIAL ACTION OBJECTIVES

Site RAOs are based on the COCs identified and TCLs developed above. The Site RAOs for groundwater are:

- Prevent exposure of onsite and offsite receptors to fractured bedrock and alluvial groundwater where COC concentrations exceed TCLs;
- Prevent future use of the underlying aquifer beneath the Site as a source of drinking water;
- Assess and manage the migration of COCs in fractured bedrock and alluvial groundwater; and
- Assess and manage the migration of COCs from fractured bedrock to the alluvium.

2.3 DEVELOPMENT OF GENERAL RESPONSE ACTIONS

GRAs are actions that may be performed in order to attempt to address the Site's RAOs. Possible GRAs for the Site include:

- No action;
- Limited action;
- Containment;
- Collection;
- Ex-situ treatment;
- Discharge; and
- In-situ treatment.

The GRAs provide a broad array of potential remedial technology types and process options to fulfill the Site RAOs. One or more broad technology types are identified for each GRA, and several process options are typically listed under each technology type. GRAs, technology types and process options are discussed further in **Section 3**.

2.4 AREAS AND VOLUMES OF IMPACTED SOURCE GROUNDWATER

The FS process requires that within the areas to be addressed by the remedial alternatives (source areas) the areas/volumes of groundwater are estimated. The areas/volumes of contaminated groundwater were estimated based on the identified source areas as described in **Section 1.4.1**.

The volume of impacted groundwater within the source areas was calculated as the volume of groundwater within the loess deposits plus the volume of groundwater within the fractures of the weathered bedrock. The volume of impacted groundwater within the loess deposits and fractures of the weathered bedrock at the two source areas was estimated at 1,202 m^3 (317,535 gallons). This estimate is likely to be a significant under-estimate of actual source mass as it does not account for COCs sorbed to sediment. Impacted groundwater volume calculations are presented in **Appendix C**.

3 SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

In this section remedial technology types and process options that are potentially applicable to groundwater COCs and conditions present at the Site are evaluated in a two-step process. The process consists of an initial identification and screening step followed by a more detailed evaluation. The overall purpose of this evaluation is to develop a focused group of remedial technologies and process options that can be used to assemble and formulate remedial action alternatives for both the fractured bedrock and the alluvium.

General Response Actions (GRAs) are broad remedial response categories that may include a number of technology types (**Section 2.3**). The term technology types refer to general categories of remedial technologies, which under the GRA of ex-situ treatment may include the technology types; physical treatment and chemical treatment. The term "process options" refers to specific processes within each technology type. For example, the technology type referred to as chemical treatment may (for groundwater) include such process options as chemical oxidation or advanced oxidation. Likewise, the technology type physical treatment may include the process options air stripping or carbon adsorption.

3.1 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

The first step in the overall evaluation of remedial technologies is the identification and screening of a large array of available remedial technologies and process options. The purpose of the screening effort is to reduce the number of available technology types and process options by eliminating technologies based primarily on technical implementability. This is accomplished by using information from the RI Report (Komex, 2005d) concerning COC types and concentrations, as well as, Site characteristics, to screen out technologies and process options that cannot be effectively implemented at the Site.

The principal source of information used for the identification of available remedial technology types and process options was the Remediation Technologies Screening Matrix and Reference Guide, Federal Remediation Technologies Roundtable (FRTR), Third Edition, November 1997 (FRTR, 1997). In addition, this information was supplemented with other technical literature and Komex's own experience.

3.1.1 FRACTURED BEDROCK

The identification and screening of remedial technologies and process options for COC impacted groundwater within the fractured bedrock are presented in **Table 3.1**. **Table 3.1** lists the possible GRAs and considers technical implementability for associated remedial technologies and process options. A description of process options, as well as conclusions concerning the technical implementability of the various process options are provided in this table.

In summary, the following process options were eliminated as part of the screening process for COC impacted groundwater within the fractured bedrock:

- Slurry Wall - A subsurface vertical wall constructed by filling a vertical excavated trench with a slurry to prevent collapse of the trench walls. The wall is backfilled with low-permeability material to form a subsurface vertical barrier which is used to contain or divert lateral groundwater flow. Slurry walls are not technically feasible due to excavation requirements within the fractured bedrock to the depths required and the potential to remobilize COCs as a consequence of the blasting requirement.
- Sheet Pile Wall - A subsurface vertical wall constructed by driving vertical sheets of steel into the ground and joining the sheets together using sealants such as grout or cement. The wall is used to contain or divert the lateral flow of groundwater. The construction of a sheet pile wall into bedrock (excavation, or driven) is not considered technically feasible
- Grout Curtain - A subsurface vertical wall constructed by injecting a grout mixture into soil pores under pressure to form a cementious mass. The wall is used to contain or divert the lateral flow of groundwater. Grout curtains are not technically feasible due to difficulties associated with forming a continuous grout curtain in fractured bedrock without remobilizing COCs.
- Interceptor Trench - Perforated horizontal pipe installed within a subsurface trench backfilled with permeable material to collect COC impacted groundwater. Vertical groundwater collection wells, which intercept the perforated horizontal pipe, extract groundwater using pumps. Interceptor trenches are not technically feasible due to excavation requirements within fractured bedrock to the depths required, and the potential to remobilize COCs as a consequence of the blasting requirement.
- Hydraulic/Pneumatic Fracturing - Techniques used to increase the permeability of silts, clays and rock by injecting highly pressurized fluid, such as sand/water slurry or air, to extend existing fractures and to create a secondary network of fissures and channels. Hydraulic/pneumatic fracturing is not technically feasible due to the potential to remobilize and/or create additional uncontrolled COC migration pathways in the bedrock.

- Explosive Fracturing - Detonation of explosives in boreholes to create an intensely fractured area of bedrock, thereby improving the interconnectedness of fractures and the potential yields of extraction wells. Explosive fracturing is not technically feasible due to the potential to create additional uncontrolled COC migration pathways and subsequent remobilization of COCs.
- Separation (Suspended Solids Filtration) - Effective method for the removal of suspended solids and metals to protect downstream treatment processes. Common filters include bag filters, sand filters and bowl filters. Separation is not an applicable technology for the treatment of Site COCs.
- Separation (Reverse Osmosis) - System uses permeable membranes to remove COCs from groundwater. A modification of the system forces groundwater through the membrane under pressure (reverse osmosis). Groundwater must be pre-treated for removal of high dissolved phase iron concentrations. Reverse osmosis has a higher cost compared to other ex-situ options, which can provide a similar or greater level of treatment
- Aeration - Pre-treatment method for the reduction of certain metal concentrations (e.g. iron) to protect downstream treatment processes from fouling or scaling. Requires follow-up clarification and/or filtration which generates sludge. May require collection and treatment of generated VOC vapors. Aeration is not an applicable technology for the treatment of Site COCs.
- Resin Adsorption - Removes VOCs from a vapor stream by adsorption onto a regenerable synthetic resin media. COC concentrations are expected to be too low for cost effective implementation of this technology.
- Precipitation/Coagulation/Flocculation - Use of chemicals to cause groundwater COCs to precipitate out of solution. Coagulant and flocculant chemicals are used to increase the precipitate particle size/mass to ease subsequent separation processes. Precipitation/coagulation/flocculation is not readily applicable to Site COCs.
- Aerobic Reactor - Microorganisms and oxygen are used to degrade organic COCs in either a suspended growth or attached growth reactors, which include activated sludge and sequencing batch reactors. An aerobic reactor is not readily applicable to Site COCs.
- Discharge for Beneficial Use (onsite and offsite Use) - Beneficial re-use of treated groundwater at the Site or off-Site. No on-Site or off-Site re-use scenarios are apparent.
- Discharge to Subsurface (Injection Well) - Discharge of treated groundwater to the subsurface using injection wells. Injection wells are prone to fouling and plugging by biomass and/or mineral scale and the process option is difficult to maintain.

- Air Sparging - In-situ air stripping of volatile COCs by injection of compressed air into groundwater. VOCs which partition into the rising air are collected by a vacuum extraction system installed in the unsaturated zone. Site conditions preclude the use of this process option, because injection of air into fractured bedrock may re-mobilize COCs, and complete collection of off gas may not be possible.
- In-Well Air stripping - Use of double-cased well with an upper and lower screen into which compressed air is injected at depth. The injected air lifts the water in the well and causes it to flow out the upper screen. Volatile COCs are partially stripped through the air lift process. Vapors are drawn off by a vacuum extraction system and treated. The discharge of water from the upper screen and intake of water through the lower screen establishes an in-situ hydraulic circulation cell through which groundwater is repeatedly circulated and treated. In-well air stripping is considered to be a pilot-scale technology. There is a lack of performance data in similar hydrogeologic settings. This process would likely also further mobilize COCs in the fractured bedrock environment.
- Permeable Reactive Barriers - Installation of an engineered, subsurface treatment zone across the flow path of a dissolved COC plume. As groundwater passes through the zone, it is treated in-situ by reactive media such as zero-valent iron, or by injection of oxygen, chemicals, or nutrients. PRBs require injection of chemicals under pressure into bedrock fractures with the potential to remobilize and/or create additional COC migration pathways. PRBs are not technically feasible due to excavation requirements within fractured bedrock to the depths required.
- Steam Injection - Steam is forced into the saturated zone to vaporize COCs. Groundwater vapors (and COCs) are collected under vacuum. Saturated zone thermal treatment is considered to be a pilot-scale technology and there is a lack of performance data in similar hydrogeologic setting. This process would likely also further mobilize COCs in the fractured bedrock environment.
- Six Phase Heating; - Six phase heating uses electrical resistivity heating to raise the temperature of the saturated zone to a point sufficient to boil groundwater. Groundwater vapors (and COCs) are collected under vacuum. Saturated zone thermal treatment is considered to be a pilot-scale technology and there is a lack of performance data in similar hydrogeologic setting.
- Enhanced Biodegradation (EBD) - EBD attempts to accelerate natural biodegradation of organic COCs to innocuous end products by providing nutrients, electron acceptors and/or microorganisms. Injection of nutrients, oxygen, and oxygen enriched water may re-mobilize COCs.

Further evaluation of the remedial technologies and process options for addressing COC impacted groundwater within the fractured bedrock that survived the initial screening step is presented in **Section 3.2.1**.

3.1.2 ALLUVIUM

The identification and screening of remedial technologies and process options for COC impacted groundwater within the alluvium are presented in **Table 3.2**. **Table 3.2** lists the possible GRAs and considers technical implementability for associated remedial technologies and process options. A description of process options, as well as conclusions concerning the technical implementability of the various process options are provided in this table.

In summary, the following process options were eliminated as part of the screening process for COC impacted groundwater within the alluvium:

- Low Permeability Cap - Compacted clay, asphalt, concrete or a geomembrane and geotextile materials installed over COC source areas to limit infiltration/recharge. Generally does not limit leaching of COCs from the smear zone into groundwater. Low permeability capping is not an applicable technology, because COC impacted soil source area is not identified in the alluvium.
- Sheet Pile Wall - A subsurface vertical wall constructed by driving vertical sheets of steel into the ground and joining the sheets together using sealants such as grout or cement. The wall is used to contain or divert the lateral flow of groundwater. The construction of a sheet pile wall to depths in excess of 70 feet bgs is not considered technically feasible.
- Horizontal/Angle-Drilled Extraction Wells - Wells drilled horizontally or on an angle offset from vertical, which are effective at locating well screens where structures and subsurface features would require the installation of a larger number of vertical-drilled wells to achieve the same objective. Specific drilling targets (fracture zones) necessitating horizontal/angle-drilled wells are not apparent. As such, this technology is unlikely to provide an advantage over conventional vertical-drilled wells.
- Hydraulic/Pneumatic Fracturing - Techniques used to increase the permeability of silts, clays and rock by injecting highly pressurized fluid, such as sand/water slurry or air, to create a secondary network of fissures and channels. Specific needs necessitating hydraulic/pneumatic fracturing are not apparent. As such, this technology is unlikely to provide an advantage over conventional collection process options.
- Explosive Fracturing - Detonation of explosives in boreholes to create an intensely fractured area of bedrock, thereby improving the interconnectedness of fractures and the potential yields of extraction wells. Specific needs necessitating explosive fracturing are not apparent.

As such, this technology is unlikely to provide an advantage over conventional collection process options.

- Aeration - Pre-treatment method for the reduction of certain metal concentrations (e.g. iron) to protect downstream treatment processes from fouling or scaling. Requires follow-up clarification and/or filtration which generates sludge. May require collection and treatment of generated VOC vapors. Aeration is not an applicable technology for the treatment of Site COCs.
- Precipitation/Coagulation/Flocculation - Use of chemicals to cause groundwater COCs to precipitate out of solution. Coagulant and flocculant chemicals are used to increase the precipitate particle size/mass to ease subsequent separation processes. Precipitation/coagulation/flocculation is not readily applicable to Site COCs.
- Aerobic Reactor - Microorganisms and oxygen are used to degrade organic COCs in either a suspended growth or attached growth reactors, which include activated sludge and sequencing batch reactors. An aerobic reactor is not readily applicable to Site COCs.
- Resin Adsorption - Removes VOCs from a vapor stream by adsorption onto a redeemable synthetic resin media. COC concentrations are expected to be too low for cost effective implementation of this technology.
- Discharge for Beneficial Re-Use - Beneficial re-use of treated groundwater at the Site or off-Site. No on-Site or off-Site re-use scenarios are apparent.
- Discharge to Subsurface - Discharge of treated groundwater to the subsurface using injection wells. Injection wells are prone to fouling and plugging by biomass and/or mineral scale and the process option is difficult to maintain.
- Air Sparging - In-situ air stripping of volatile COCs by injection of compressed air into groundwater. VOCs which partition into the rising air are collected by a vacuum extraction system installed in the unsaturated zone. Site conditions preclude the use of this process option. Interbedded clays, silts and sands, commonly found in alluvial sediments potentially result in poor air sparge off gas collection.
- In-well Air Stripping - Use of double-cased well with an upper and lower screen into which compressed air is injected at depth. The injected air lifts the water in the well and causes it to flow out the upper screen. Volatile COCs are partially stripped through the air lift process. Vapors are drawn off by a vacuum extraction system and treated. The discharge of water from the upper screen and intake of water through the lower screen establishes an in-situ hydraulic circulation cell through which groundwater is repeatedly circulated and treated. In-well air stripping is considered to be a pilot-scale technology. There is a lack of performance data in similar hydrogeologic setting.

- Steam Injection - Steam is forced into the saturated zone to vaporize COCs. Groundwater vapors (and COCs) are collected under vacuum. Saturated zone thermal treatment is considered to be a pilot-scale technology and there is a lack of performance data in similar hydrogeologic setting.
- Six-Phase Heating - Six phase heating uses electrical resistivity heating to raise the temperature of the saturated zone to a point sufficient to boil groundwater. Groundwater vapors (and COCs) are collected under vacuum. Saturated zone thermal treatment is considered to be a pilot-scale technology and there is a lack of performance data in similar hydrogeologic setting.

Further evaluation of the remedial technologies and process options for addressing COC impacted groundwater within the alluvium that survived the initial screening step is presented in **Section 3.2.2**.

3.2 EVALUATION AND SELECTION OF TECHNOLOGIES AND PROCESS OPTIONS

In this step, the remedial technologies and process options retained from the previous screening step are evaluated in detail to further focus the development of remedial action alternatives. This step involves evaluating process options within the same technology type based on the criteria of effectiveness, implementability, and cost. One representative process is typically selected for each technology type to simplify the subsequent development and evaluation of remedial alternatives, without limiting flexibility during remedy selection or remedial design. For some technology types however, more than one process option may be selected if the processes are sufficiently different in their performance, such that one would not adequately represent the other, or if variable site and contaminant characteristics warrant consideration of multiple process options to address the same medium. The evaluation of process options is carried out in this step for the COC impacted fractured bedrock and alluvial ground water. The processes retained from this evaluation are then used to assemble remedial action alternatives for the fractured bedrock and alluvial portion of the contaminant plume.

In accordance with USEPA guidance (USEPA, 1988a), brief descriptions of effectiveness, implementability, and relative cost, as they apply to the evaluation process are provided below:

<u>Effectiveness</u> - This criterion focuses on the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the RAOs; the potential impacts to human health and the environment during the construction and implementation phase; and how proven and reliable the process is with respect to the COCs and conditions at the Site.

Implementability - This criterion encompasses both the technical and administrative feasibility of implementing a process. Technical implementability was used in **Section 3.1** as an initial screen of technology types and process options to eliminate those that are clearly ineffective or impractical at the Site. This subsequent, more detailed evaluation of process options will place greater emphasis on the institutional aspects of implementability: such as the ability to obtain permits for offsite actions or fulfill the substantive requirements of ARARs for onsite actions; the availability of treatment, storage, and disposal services; and availability of equipment and other resources.

Cost - This criterion plays a limited role in the screening of process options. Relative capital and operation and maintenance (O&M) costs will be used rather than detailed estimates. The cost analysis will be based on engineering judgment and each process will be evaluated as to whether costs are high, medium, or low relative to other processes in the same technology type.

Consistent with USEPA guidance (USEPA, 1988a), the detailed evaluation that follows is focused on effectiveness factors, with less effort directed at the implementability and cost evaluation.

3.2.1 FRACTURED BEDROCK

This section presents the evaluation and selection of technologies and process options for addressing impacted groundwater within the fractured bedrock. As described above, potential groundwater remediation technologies and process options for the fractured bedrock, which are carried forward from the preceding screening step are evaluated in detail with respect to effectiveness, implementability, and cost. The remedial technologies and process options, which are retained, because of this more detailed evaluation step will be used to assemble remedial action alternatives as presented in **Section 4.0**.

The ensuing discussion is organized according to the following seven GRAs initially identified in **Section 2.3**:

- No Action;
- Limited Action;
- Containment;
- Collection;
- Ex-situ treatment;
- Discharge; and
- In-situ treatment.

A summary of the evaluation of remedial technologies and process options for COC impacted groundwater within the fractured bedrock is presented in **Table 3.3**.

3.2.1.1 No Action

The GRA termed "No Action" is carried forward for evaluation because it provides a baseline to which other general response actions and their associated remedial technologies can be compared. "No Action" entails no activities to contain or remediate COCs at the Site, provides no treatment for COCs, and provides no legal or administrative protection of human health or the environment beyond cleanup criteria. "No Action" assumes that physical conditions at the Site remain unchanged and does not preclude that natural attenuation, including advection, dilution, and dispersion, will act to reduce the concentration of COCs in groundwater. However, verification that natural attenuation processes are operating is not possible because groundwater monitoring is assumed not to take place as part of this GRA.

Effectiveness. "No Action" generally would not achieve the RAOs for the Site. Groundwater would continue to exhibit COC concentrations in excess of TCLs, and no institutional controls would be in-place to limit exposure to contaminated groundwater and restrict future use of impacted groundwater.

Implementability. There are no implementability limitations associated with the "No Action" GRA.

Cost. There are no capital costs or O&M costs associated with the "No Action" GRA.

Conclusion. The "No Action" GRA is retained as required by CERCLA and the NCP as a baseline with which to compare other remedial alternatives.

3.2.1.2 Limited Action

The following Limited Action remedial technologies and process options, which were retained in the screening step as potentially applicable to COC impacted groundwater within the fractured bedrock are evaluated in this section:

Remedial Technology	Process Option
Institutional Controls	Land and Resource Use Restriction
Wellhead Treatment	Wellhead Treatment Systems
Long-Term Monitoring	Groundwater Monitoring

3.2.1.2.1 Institutional Controls

ICs are non-engineering measures used to manage site risks by limiting potential exposure to COCs and/or by protecting and ensuring the integrity of the remedy. Examples of ICs cited in the NCP, include land and resource use restrictions (e.g., water), well-drilling prohibitions, building permits, well use advisories and deed notices. ICs, such as land use and access restriction manage human health risk by limiting the potential for exposure from ingestion and dermal contact with groundwater and inhalation of COCs. ICs could also include health and safety policies and procedures to limit exposure to groundwater COCs during construction activities.

Effectiveness. ICs do not meet all the Site RAOs as they do nothing to reduce the mobility, toxicity, or volume of COCs at the Site, although they are effective for reducing risk to human health. The effectiveness of ICs depends on the mechanisms used and the durability of the IC. Land and resource use restrictions are considered effective. No additional risks to human health and the environment would directly result from the imposition of ICs.

Implementability. ICs could be implemented as a stand-alone remedy or in combination with other alternatives. ICs that are developed as part of an alternative may require administrative activity and legal action on the part of the Property owner, the State and/or local authorities.

Cost. Capital and O&M costs for institutional controls are considered low compared to other Limited Action process options.

Conclusion. Although ICs acting alone do not adequately address the groundwater RAOs for the Site, they are effective for reducing risk to human health. This option is therefore retained because it can be an important component of several remedial alternatives since groundwater COCs are expected to persist at levels above TCL concentrations for a number of years, even under active remediation scenarios.

3.2.1.2.2 Wellhead Treatment Systems

This option involves the installation of wellhead treatment systems at any existing potable water supply well in the event that one becomes impacted by COCs, or new potable water supply wells are installed where extracted groundwater could be reasonably expected to have COC concentrations greater than TCLs. The treatment system is termed "wellhead" because it is installed at the wellhead of the water supply well. Air strippers and carbon adsorption units, either alone or in series, are the most common types of wellhead treatment systems for VOCs and SVOCs.

Effectiveness. Wellhead treatment is an effective method to reduce risks to human health through exposure to impacted groundwater. Typically, drinking water supply wells are not used to extract groundwater for the purpose of containing or remediating a COC groundwater plume, although, gradually over time, TCLs may be achieved in the extraction well groundwater capture zone. This option on its own is not designed to achieve the RAOs for Site groundwater in the fractured bedrock.

Implementability. Wellhead treatment is readily implemented using conventional, commercially available equipment.

Cost. The capital and O&M costs for wellhead treatment are considered moderate compared to other Limited Action technologies, although this depends on the number of wellhead treatment systems required and the duration of operation.

Conclusion. Although wellhead treatment acting alone does not adequately address the Site RAOs, it does reduce risk to human health. This option is retained since groundwater COCs are expected to persist at levels above TCL concentrations for a number of years, even under active remediation scenarios, and this option could be an important component of several remedial alternatives.

3.2.1.2.3 Groundwater Monitoring

Groundwater monitoring, which would involve the periodic collection of groundwater samples for laboratory analysis, can be used to evaluate changes in groundwater quality conditions resulting from leaching and migration. Monitoring can also be used to assess the effectiveness of groundwater remediation measures.

Effectiveness. Groundwater monitoring is not effective for reducing risk to human health and is not effective in attaining RAOs for groundwater. However, this option is an effective tool for assessing the migration and concentrations of COCs in groundwater.

Implementability. A long-term groundwater monitoring program could be readily implemented using conventional techniques and the monitoring and sampling procedures currently used at the Site.

Cost. The capital and O&M costs for long-term groundwater monitoring are considered to be low and moderate, respectively, compared to other Limited Action technologies.

Conclusion. Although groundwater monitoring does not address RAOs for the Site, this option could be used to assess the migration of COCs in groundwater and as a measure of the effectiveness of other components of a remedial alternative, particularly as part of annual and five-year Site reviews. Therefore, it is retained for possible use as part of a remedial action alternative.

3.2.1.3 Containment

Containment technologies refer to methods, which are intended to limit/prevent the mobilization and migration of COCs, as well as measures which limit/prevent direct human and ecological contact with COCs. Containment may not remove COCs, reduce their concentrations, or actively alter their chemical state. Containment measures for impacted groundwater typically include low-permeability capping, hydraulic gradient controls and vertical barriers. COC removal (as a consequence of a gradient control system) may gradually achieve TCLs within the contained area.

Low-permeability capping was retained in the screening step as potentially applicable to the portion of the Site underlain by fractured bedrock. Low-permeability capping is a groundwater containment technology intended to form a horizontal infiltration/recharge barrier, which also limits leaching and migration of COCs from soil into groundwater. Typically, when used alone, low-permeability caps only reduce leaching of COCs from vadose zone soils (i.e., by reducing/eliminating infiltration). COCs located at/or below the water table (i.e., smear zone), would continue to leach to groundwater. Caps are often utilized in conjunction with vertical barriers to improve contaminant isolation or recovery techniques. When combined with a vertical barrier and groundwater extraction, low-permeability caps may assist in the reduction/elimination of leaching of COCs in groundwater from the smear zone.

The following low-permeability capping process options for COC impacted groundwater within the fractured bedrock were retained in the screening step:

Remedial Technology	Process Option
Low Permeability Capping	Clay/Soil Cap
	Asphalt Cap
	Concrete
	Geosynthetic/Multimedia

The clay/soil cap process option has been selected to represent the low-permeability capping technology because it is considered equally effective when compared to the other process options, and its costs are lower. The clay/soil capping process option is evaluated below.

3.2.1.3.1 Clay/Soil Cap

This option would involve the placement of a clay layer over COC impacted soils to limit the infiltration of precipitation and associated leaching of residual soil COCs into groundwater. In general, this and other low-permeability caps only reduce leaching of COCs from vadose zone soils. COCs at/or below the water table (i.e., smear zone) would continue to leach to groundwater. The clay cap would be covered with topsoil and vegetation to protect the clay from weathering and erosion.

Effectiveness. The locations of residual COCs have been tentatively identified based upon groundwater sampling. Residual COCs may be located at depth and in isolated zones, separated by areas without residual COCs. The clay/soil cap will therefore have limited effectiveness if the locations of the residual COCs aren't covered. The clay/soil cap is only effective for COCs in the vadose zone. Capping will not reduce residual soil or groundwater COC concentrations. In addition, the long-term effectiveness of a clay/soil cap may be reduced by weather-related and biota-related deterioration, and hence would require routine inspection and maintenance. This process option does not achieve Site RAOs, and in order to be effective, must be combined with other containment remedial technologies.

Implementability. The construction of a clay/soil cap is considered to be readily implementable. However, the implementation and future enforcement of ICs, which would be required in conjunction with this option to prevent human excavation or penetration of the cap, is potentially more problematic.

Cost. The capital and O&M costs for a clay/soil cap are considered moderate compared to the other low-permeability capping options previously screened and eliminated.

Conclusion. Although a clay/soil cap would limit the infiltration of precipitation and associated leaching of residual soil COCs into groundwater without a vertical barrier (which was eliminated in the initial screening step due to technical feasibility), COCs at or below the water table would continue to leach to groundwater. Therefore, the clay/soil cap process option and containment as a GRA has been eliminated from further consideration due to limited effectiveness.

3.2.1.4 Collection

Groundwater collection refers to technologies that are used to collect, withdraw, or extract COC impacted groundwater by passive or active means. Collection physically removes COC impacted groundwater from the subsurface and is typically coupled with ex-situ treatment processes to remove the COCs from the groundwater before it is discharged to either a surface water, groundwater, or is reused. A combination of collection, ex-situ treatment and discharge, also described as pump and treat, is used to provide hydraulic containment and to reduce groundwater COCs. Ex-situ treatment technologies for groundwater are evaluated in **Section 3.2.1.5**, and discharge options are evaluated in **Section 3.2.1.6**.

Most of the collection process options considered for COC impacted groundwater within the fractured bedrock were screened out due to technical implementability concerns. The following groundwater collection process options were retained in the screening step for COC impacted groundwater within the fractured bedrock:

Remedial Technology	Process Option
Extraction (Groundwater Pumping)	Vertical-Drilled Extraction Wells
	Horizontal/Angled-Drilled Wells
Dual-Phase Extraction	Dual-Phase Extraction

Given the complex nature of the discrete fracturing of the bedrock, and the importance of vertical fractures in controlling and dominating groundwater flow and COC transport within bedrock, angled-drilled extraction wells are judged to have an advantage over vertical wells in terms of the likelihood of intersecting target vertical fracture zones and as such, have been selected to represent the groundwater collection technology. Dual-phase extraction was not considered to best represent groundwater collection as it is typically more expensive than groundwater pumping and is not considered to offer a higher level of treatment. The angled-drilled extraction well process option is evaluated below.

3.2.1.4.1 Angle-Drilled Extraction Wells

An angle-drilled extraction well system consists of a series of wells, which are installed at an angle other than 90 degrees to the ground surface, and equipped with pumps (typically submersible) to capture impacted groundwater. Angle-drilled extraction wells, when compared to other groundwater collection options (such as vertical wells) are typically more expensive to implement, as they require specialized drilling equipment for installation. At this Site, angle-drilled wells offer a higher probability of success in intercepting target vertical fracture zones when compared to more conventional vertical-drilled wells.

Effectiveness. Given that groundwater migrates through fractures and bedding planes in the bedrock and the distribution of COC in groundwater is controlled by the presence of mainly vertical fractures (Komex, 2005d), the effectiveness of this remedial technology will depend upon the technology's ability to extract COC impacted groundwater, which in turn relates to the identification of major vertical fractures and the predictability of the exact location of these fractures.

During characterization, attempts were made to identify the individual major vertical fractures responsible for COC migration. Well MW-12 was successful in intersecting such a fracture. COC concentrations above the laboratory RL were measured in samples from well MW-12. However, well MW-13, completed in what appeared to be a similar, parallel vertical fracture approximately 35 feet to the east of well MW-12, yielded no COC concentrations above their respective RLs. Similarly, samples collected from wells installed down-gradient in the fractured bedrock, in the presumed direction of COC transport, did not contain measurable COC concentrations above the RLs. If all the fractures, which are actually transporting COCs off-Property, cannot be identified or located exactly, then the effectiveness of the process option to collect COC impacted groundwater from the fractured bedrock is considered negligible. Furthermore, due to the complex fracture network configuration and the difficulty in detecting which fractures actually contain COCs and which do not, active pumping of groundwater via angled-drilled wells also has the significant risk of redistributing COCs within unimpacted fractures and causing further spreading of the plume.

Angle-drilled extraction wells are not effective for reducing risk to human health as they do not restrict use of the groundwater and therefore, on their own do not achieve all the Site RAOs. In addition, during implementation, workers may be exposed to extracted COC impacted groundwater or soils.

Implementability. An angle-drilled extraction well system is considered difficult to implement at the Site as it requires specialized drilling equipment and techniques. To ensure intersection of identified target fracture zones, it is foreseeable that a large number of wells would be required. Uncertainties regarding the location of all the fractures actually transporting COCs offsite potentially further increase the number of required wells. The implementation of a large bedrock drilling program using angle-drilled wells, targeting an uncertain number of fracture zones, in uncertain locations, is considered difficult and practically infeasible.

Cost. The capital and O&M costs for angle-drilled extraction wells are considered high and moderate, respectively, when compared to other groundwater collection technologies screened out earlier.

Conclusion. Angle-drilled extraction wells in fractured bedrock have limited effectiveness and may cause the spread of contamination, are considered very difficult to implement and are likely to be very costly, requiring specialized equipment. This process option, based on effectiveness and implementability, is eliminated as a potential component of remedial action alternatives that are focused on COC impacted groundwater within the fractured bedrock.

3.2.1.5 Ex-Situ Treatment

The general response action for groundwater termed "ex-situ treatment" refers to technologies and associated process options used to treat contaminated groundwater after it has been withdrawn from the subsurface. Treatment of contaminated groundwater in-place is termed "in-situ treatment" and is evaluated in **Section 3.2.1.7**. A key advantage of ex-situ treatment over in-situ treatment is that there is more certainty about the uniformity, delivery and effectiveness of treatment because there is an ability to directly monitor and control the treatment process. Ex-situ treatment, however, typically requires pumping, treatment, and subsequent discharge of groundwater, which leads to increased costs and engineering requirements for equipment, permitting (or compliance with substantive ARAR requirements [**Appendix B**]), residuals treatment, and handling/disposal requirements (FRTR, 1997).

The following groundwater collection process options were retained in the screening step for COC impacted groundwater within the fractured bedrock:

Remedial Technology	Process Option
Physical Treatment	Aeration
	Air Stripping
	Carbon Adsorption
Chemical Treatment	Chemical Oxidation
	Advanced Oxidation

Given that groundwater collection process options were eliminated in **Section 3.2.1.4**, and given that the application of ex-situ treatment process options are dependent upon groundwater collection processes, the consideration of ex-situ treatment for COC impacted groundwater within the fractured bedrock is no longer applicable.

3.2.1.6 Discharge

Groundwater discharge refers to technologies for the ultimate disposition of groundwater following collection and ex-situ treatment. The following groundwater discharge process options were retained in the screening step for COC impacted groundwater within the fractured bedrock:

Remedial Technology	Process Option
Surface Discharge	Direct Discharge
	Indirect Discharge

Similar to ex-situ treatment process options, the retained discharge process options are no longer applicable to COC impacted groundwater within the fractured bedrock given their dependence on groundwater collection and ex-situ process options, which were eliminated in **Sections 3.2.1.4** and 3.2.1.5.

3.2.1.7 In-Situ Treatment

The general response action termed "In-situ Treatment" refers to technologies and associated process options, which are used to treat contaminated groundwater in place without pumping to a surface treatment system. Ex-situ treatment options, which refer to treatment of groundwater following withdrawal from the subsurface, were evaluated in **Section 3.2.1.5**. The main advantages of in-situ treatment over ex-situ treatment are the elimination of groundwater extraction and the subsequent need for discharge, the attendant costs, treatment residuals handling/disposal, safety, and permitting/ARAR compliance issues. Disadvantages of in-situ treatment compared to an ex-situ treatment system include, uncertainties regarding treatment uniformity, delivery and effectiveness due to an inability to directly monitor and control the treatment process (FRTR, 1997).

In-situ process options, with the exception of monitored natural attenuation (MNA), were eliminated in the screening step for COC impacted groundwater within the fractured bedrock due to several treatment limitations (i.e., limited accessibility to COCs, hydraulic conductivity variability, and reduced ability to contact dispersed COCs) posed by the fractured bedrock environment at the Site, and concerns regarding the potential to redistribute COCs within unimpacted fractures and cause further spreading of the plume. The evaluation of MNA is discussed below.

3.2.1.7.1 Monitored Natural Attenuation

The USEPA guidance document "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, And Underground Storage Tank Sites" (Office of Solid Waste and Emergency Response Programs [OSWER] Directive 9200.4-17) (USEPA, 1997) clarifies the USEPA's policy regarding the use of MNA at fractured bedrock sites. The OSWER directive states the following:

"In some complex geological systems, technological limitations may preclude adequate monitoring of a natural attenuation remedy to ensure with a high degree of certainty that potential receptors will not be impacted. This situation typically occurs in many karstic, structured, and/or fractured rock aquifers, where groundwater moves preferentially through discrete channels. The direction of groundwater flow through such heterogeneous (and often anisotropic) materials cannot be predicted directly from the hydraulic gradient, and existing techniques may not be capable of identifying the channels that carry contaminated groundwater through the subsurface. Monitored natural attenuation will not generally be appropriate where site complexities preclude adequate monitoring."

Given USEPA policy regarding the use of MNA at fractured bedrock sites, MNA as a process option applicable to COC impacted groundwater within the fractured bedrock was eliminated based on the technical infeasibility to monitor natural attenuation processes with a high degree of certainty.

3.2.1.8 Summary of Selected Technologies and Process Options

On the basis of screening and evaluation of technologies and process options discussed herein and summarized in **Table 3.3**, remedial action alternatives for COC impacted groundwater within the fractured bedrock will be assembled from the following:

General Response Action	Remedial Technology	Process Option
No Action	Not Applicable	Not Applicable
Limited Action	Institutional Controls	Land and Resource Use Restrictions
	Wellhead Treatment	Wellhead Treatment Systems
	Long-Term Monitoring	Groundwater Monitoring

Active remedial technologies, such as in-situ or ex-situ treatment, were eliminated as part of the screening and detailed evaluation steps. The implementation of the retained process options either on their own or in combination, as remedial action responses, will not meet all the Site

RAOs. The retained process options will not manage the migration of COCs in groundwater; however, the implementation of ICs and wellhead treatment will reduce risks to human health by preventing use of the aquifer beneath the Site as a source of drinking water and preventing exposure to impacted groundwater.

3.2.2 ALLUVIUM

This section presents the evaluation and selection of technologies and process options for addressing impacted groundwater within the alluvium. As described in previous sections, potential groundwater remediation technologies and process options for the alluvium, which are carried forward from the preceding screening step are evaluated in detail with respect to effectiveness, implementability, and cost. The remedial technologies and process options, which are retained, because of this more detailed evaluation step will be used to assemble remedial action alternatives as presented in **Section 4.0**.

The ensuing discussion is organized according to the following seven GRAs initially identified in **Section 2.3**:

- No Action;
- Limited Action;
- Containment;
- Collection;
- Ex-situ treatment;
- Discharge; and
- In-situ treatment.

A summary of the evaluation of remedial technologies and process options for COC impacted groundwater within the alluvium is presented in **Table 3.4**.

3.2.2.1 No Action

The GRA termed "No Action" is carried forward for evaluation because it provides a baseline to which other general response actions and their associated remedial technologies can be compared. "No Action" entails no activities to contain or remediate COCs within the alluvium at the Site, provides no treatment for COCs, and provides no legal or administrative protection of human health or the environment beyond cleanup criteria. "No Action" assumes that physical conditions at the Site remain unchanged and does not preclude that natural attenuation, including advection, dilution, and dispersion, will act to reduce the concentration of COCs in groundwater. However, verification that natural attenuation processes are operating is not possible because groundwater monitoring is assumed not to take place as part of this GRA.

Effectiveness. "No Action" generally would not achieve the RAOs for the Site. Groundwater would continue to exhibit COC concentrations in excess of TCLs, and no institutional controls would be in-place to limit exposure to contaminated groundwater and restrict future use of impacted groundwater.

Implementability. There are no implementability limitations associated with the "No Action" GRA.

Cost. There are no capital costs or O&M costs associated with the "No Action" GRA.

Conclusion. The "No Action" GRA is retained as required by CERCLA and the NCP as a baseline with which to compare other remedial alternatives.

3.2.2.2 Limited Action

The following Limited Action remedial technologies and process options, which were retained in the screening step as potentially applicable to COC impacted groundwater within the alluvium are evaluated in this section:

Remedial Technology	Process Option
Institutional Controls	Land and Resource Use Restriction
Wellhead Treatment	Wellhead Treatment Systems
Long-Term Monitoring	Groundwater Monitoring

3.2.2.2.1 Institutional Controls (ICs)

ICs are non-engineering measures used to manage site risks by limiting potential exposure to COCs and/or by protecting and ensuring the integrity of the remedy. Examples of ICs cited in the NCP, include land and resource use restrictions (e.g., water), well-drilling prohibitions, building permits, well use advisories and deed notices. ICs, such as land use and access restriction manage human health risk by limiting the potential for exposure from ingestion and dermal contact with groundwater and inhalation of VOCs. ICs could also include health and safety policies and procedures to limit exposure to groundwater COCs during construction activities.

Effectiveness. ICs do not meet all the Site RAOs as they do nothing to reduce the mobility, toxicity, or volume of COCs at the Site, although they are effective for reducing risk to human health. The effectiveness of ICs depends on the mechanisms used and the durability of the IC. Land and resource use restrictions are considered effective. No additional risks to human health and the environment would directly result from the imposition of ICs.

Implementability. ICs could be implemented as a stand-alone remedy or in combination with other alternatives. ICs that are developed as part of an alternative may require administrative activity and legal action on the part of the Property owner, the State and/or local authorities.

Cost. Capital and O&M costs for institutional controls are considered low compared to other Limited Action process options.

Conclusion. Although ICs acting alone do not adequately address the groundwater RAOs for the Site, they are effective for reducing risk to human health. This option is therefore retained because it can be an important component of several remedial alternatives since groundwater COCs are expected to persist at levels above TCL concentrations for a number of years, even under active remediation scenarios.

3.2.2.2.2 Wellhead Treatment Systems

This option involves the installation of wellhead treatment systems at any existing potable water supply well in the event that one becomes impacted by COCs, or new potable water supply wells are installed where extracted groundwater could be reasonably expected to have COC concentrations greater than TCLs. The treatment system is termed "wellhead" because it is installed at the wellhead of the water supply well. Air strippers and carbon adsorption units, either alone or in series, are the most common types of wellhead treatment systems for VOCs and SVOCs.

Effectiveness. Wellhead treatment is an effective method to reduce risks to human health through exposure to impacted groundwater. Typically, drinking water supply wells are not used to extract groundwater for the purpose of containing or remediating a COC groundwater plume, although, gradually over time, TCLs may be achieved in the extraction wells groundwater capture zone. This option on its own is not designed to achieve the RAOs for Site groundwater in the alluvium.

Implementability. Wellhead treatment is readily implemented using conventional, commercially available equipment.

Cost. The capital and O&M costs for wellhead treatment are considered moderate, although this depends on the number of wellhead treatment systems required and the duration of operation.

Conclusion. Although wellhead treatment acting alone does not adequately address the Site RAOs, it does reduce risk to human health. This option is retained since groundwater COCs are expected to persist at levels above TCL concentrations for a number of years, even under active remediation scenarios, and this option could be an important component of several remedial alternatives.

3.2.2.2.3 Groundwater Monitoring

Groundwater monitoring, which would involve the periodic collection of groundwater and samples for laboratory analysis, can be used to evaluate changes in groundwater quality conditions resulting from leaching and migration. Monitoring can also be used to assess the effectiveness of groundwater remediation measures.

Effectiveness. Groundwater monitoring is not effective for reducing risk to human health and is not effective in attaining RAOs for groundwater. However, this option is an effective tool for assessing the migration and concentrations of COCs in groundwater.

Implementability. A long-term groundwater monitoring program could be readily implemented using conventional techniques and procedures previously used at the Site.

Cost. The capital and O&M costs for long-term groundwater monitoring are considered to be low and moderate, respectively, compared to other Limited Action technologies.

Conclusion. Although groundwater monitoring alone does not address RAOs for the Site, this option could be used to assess the migration of COCs in groundwater and as a measure of the effectiveness of other components of a remedial alternative, particularly as part of annual and five-year Site reviews. Therefore, it is retained for possible use as part of a remedial action alternative.

3.2.2.3 Containment

Vertical barriers applied to the portion of the Site underlain by alluvium were retained for further evaluation. Vertical barriers are used to contain COC impacted groundwater, divert COC impacted groundwater from a drinking water intake, divert groundwater flow, and/or provide a barrier for a groundwater treatment system. These subsurface barriers can consist of either a vertically excavated trench filled with a slurry, or a series of closely spaced wells injected with grout to form a continuous vertical grout curtain. However, uncertainties exist regarding the formation of a continuous vertical grout curtain in a stratified geological deposit, such as the alluvium. A trench-constructed barrier would provide a higher level of containment compared to grout injection wells and as such, better represents the vertical containment GRA.

The following vertical containment process option for alluvial groundwater retained in the screening step, is evaluated in this section:

Remedial Technology	Process Option
Vertical Barrier	Slurry Walls

3.2.2.3.1 Slurry Walls

Slurry walls are a full-scale technology that has been used for decades as long-term solutions to control seepage. They are often used in conjunction with low-permeability capping. Typically, slurry walls are used where the waste mass is too large for treatment and where soluble and mobile constituents pose an imminent threat to a source of drinking water. Slurry walls are typically installed to depths of up to 100 feet bgs and are generally 2 to 4 feet in thickness. The deeper installation depths are implementable using a clamshell bucket excavator, but the cost per unit area of wall increases by an approximate factor of three. Most slurry walls are constructed of a mixture consisting of soil, Bentonite, and water. The Bentonite slurry is used primarily for wall stabilization during trench excavation. A soil-Bentonite backfill material is then placed into the trench (displacing the slurry) to create the cutoff wall. The most effective application of the slurry wall is to base (or key) the slurry wall approximately 2 to 3 feet into a low permeability layer, such as a clay.

Effectiveness. The slurry wall process option has a demonstrated effectiveness in containing groundwater; however, in COC impacted groundwater applications, specific contaminant types may degrade the slurry wall components and reduce the long-term effectiveness. The installation of a slurry wall requires considerable intrusive action. Large volumes of COC impacted waste will be generated and heavy construction equipment will be used. The installation of the slurry wall poses risks to human health such as exposure to COC impacted soil and groundwater, and risks associated with working with heavy construction equipment. This process option does not restrict the use of the aquifer for drinking water and does not achieve the Site RAOs. Since the source location of discharge of COCs to the alluvium groundwater at depth from the bedrock is unknown, this process option is not considered effective.

Implementability. A clay layer exists beneath the wetland at a depth of approximately 100 feet bgs. To key the slurry wall into the underlying clay will require deep excavation and specialized heavy construction equipment. Large volumes of material will need to be transported to and from the Site to complete the installation, and the construction of temporary haul roads across the wetland are foreseeable. In addition to difficulties associated with the slurry wall installation, the implementation and future enforcement of ICs, which would be required in conjunction with this option to prevent human excavation of the barrier, is potentially problematic. In addition, the installation of a slurry wall in the wetlands area will have to comply with location-specific ARARs such as, the Protection of Wetland (Executive Order 11990) (**Appendix B, Table B-2**). Since the source location of discharge of COCs to the alluvium groundwater at depth from the bedrock is unknown, this process option is not considered implementable.

Cost. The capital and O&M costs for a slurry wall are considered high and moderate compared to the other containment GRA previously screened and eliminated.

Conclusion. A slurry wall does not meet all of the Site RAOs and poses additional human health risks because of its installation. Since the source location of discharge of COCs to the alluvium groundwater at depth from the bedrock is unknown, this process option is not considered effective or implementable. The construction of a deep slurry wall in the wetland area is considered difficult and costly. Therefore, the slurry wall process option has been eliminated from further consideration due to possible reduced long-term effectiveness, increased short term health risks, the difficulties foreseen for implementation, and the high cost.

3.2.2.4 Collection

The following groundwater collection process options were retained in the screening step for COC impacted groundwater within the alluvium:

Remedial Technology	Process Option
Extraction (Groundwater Pumping)	Vertical-Drilled Extraction Wells
	Interceptor Trenches

3.2.2.4.1 Vertical-Drilled Extraction Wells

A vertical-drilled extraction well system consists of a series of wells, which are installed perpendicular to ground surface, and equipped with pumps (typically submersible) to capture impacted groundwater.

Effectiveness. The effectiveness of vertical-drilled extraction wells to extract groundwater is controlled primarily by the permeability of the aquifer. The effectiveness of groundwater extraction is limited in aquifers with low hydraulic conductivity that require a large number of wells to achieve capture of a COC plume. Vertical-drilled wells do not reduce human health risks, as they do not restrict use of the groundwater, therefore, vertical-drilled wells do not, on their own, achieve all the Site RAOs. In addition, the installation of vertical-drilled extraction wells potentially exposes workers to COC impacted soils and groundwater.

Implementability. A vertical-drilled extraction well system is considered moderate to difficult to implement for the alluvium at the Site. Despite the fact that wells can be drilled using standard readily available drilling equipment and techniques, implementation requires movement of heavy equipment over the wetland (unstable ground conditions).

Cost. The capital and O&M costs for vertical-drilled extraction wells are considered moderate compared to other groundwater collection technologies.

Conclusion. Vertical-drilled extraction wells are considered potentially effective and are moderately difficult to implement using standard drilling equipment and considering the limitations of access and disruption/damage to the wetlands. This process option does not achieve Site RAOs but is retained as a potential component of remedial action alternatives focused on COC impacted alluvial groundwater.

3.2.2.4.2 Interceptor Trenches

Interceptor trenches are commonly applied in situations where shallow groundwater is to be extracted. An interceptor trench is a linear vertical excavation backfilled with permeable material and equipped with collection pipes and pumps. The interceptor trench captures impacted groundwater by collecting groundwater in perforated horizontal pipes installed at the base of the trench, which then connect to vertical pipes equipped with groundwater extraction pumps (typically submersible).

Effectiveness. The effectiveness of the interceptor trench is governed by the permeability of the backfill material and, in particular, the permeability of the perforated horizontal collection pipe. Biological activity and sedimentation around the pipe can lead to clogging of pipe perforations and reduction in groundwater collection efficiency. Unlike vertical-drilled extraction wells, rehabilitation measures (application of biocides and flushing (well development) are difficult to implement and unlikely to be successful in improving long term effectiveness.

An interceptor trench does not reduce human health risks, as it does not restrict use of the groundwater, therefore, an interceptor trench does not, on its own, achieve all the Site RAOs. In addition, the installation of an interceptor trench requires considerable intrusive action. Large volumes of COC impacted waste will be generated and heavy construction equipment will be used. The installation of an interceptor trench poses additional risks to human health such as exposure to COC impacted soil and groundwater, and risks associated with working with heavy construction equipment.

Implementability. The thickness and depth of COC impacted alluvium will reduce the implementability of this process option at the Site. Groundwater modeling (Komex 2005e) indicates that bedrock fractures potentially discharge dissolved-phase COCs at depths possibly in excess of 70 feet bgs. Installation of interceptor trenches to these depths requires either stable ground conditions or trench supports. Ground conditions in the wetland area (clays and silts) are likely to be unstable and an unsupported trench excavated to depths greater than 70 feet is likely to collapse. The use of biopolymer-enriched water to support the trench sides requires specialized excavation techniques and equipment, such as a clamshell excavator. The operation of heavy construction equipment on the wetland, such as the clamshell excavator and support equipment including pump trucks, water trucks, etc., is likely to be problematic.

An interceptor trench excavated to 70 feet bgs cannot be implemented using readily available equipment and will require specialized equipment and excavation techniques. In addition, the implementation of an excavation activity in the wetlands area will have to comply with location-specific ARARs such as, the Protection of Wetland (Executive Order 11990) (**Appendix B, Table B-2**). Since the source location of discharge of COCs to the alluvium groundwater at depth from the bedrock is unknown, and for other reasons noted above, this process option is not considered implementable.

Cost. The capital and O&M costs for a deep interceptor trench are considered high and moderate, respectively, compared to other groundwater collection technologies.

Conclusion. Deep interceptor trenches are considered potentially ineffective over a long period, are difficult to implement requiring specialized equipment and excavation techniques, are limited due to uncertainty regarding source location, will be restricted by the limitations of access and disruption/damage to the wetlands and are likely to be costly compared to other collection technologies. This process option is therefore eliminated as a potential component of remedial action alternatives focused on COC impacted alluvium groundwater.

3.2.2.5 Ex-Situ Treatment

The following groundwater ex-situ treatment process options were retained in the screening step for COC impacted groundwater within the alluvium:

Remedial Technology	Process Option
Physical Treatment	Air Stripping
	Carbon Adsorption
	Vapor Phase Carbon Adsorption
Chemical Treatment	Chemical Oxidation
	Advanced Oxidation

3.2.2.5.1 Air Stripping

Air stripping is a process in which VOCs are transferred from the aqueous phase to the vapor phase by contacting the contaminated water with air; typically in a countercurrent manner to increase the mass transfer surface area. Air stripping is typically accomplished using packed towers or bubble-tray aerators, although aspirators, diffusers, and spray aeration can also be used. Air stripping generates VOC vapor emissions, which may require treatment controls depending on their concentrations.

Effectiveness. Air stripping is a well-developed, widely used process for removal of many dissolved halogenated and non-halogenated VOCs, including those present in Site groundwater. Air stripping is considered by USEPA to be a "presumptive technology" for ex-situ treatment of dissolved VOCs under the Superfund Accelerated Clean-up Model; however, given relatively low concentrations of COCs in the alluvium (less than 15 ug/L), air stripping may not be the most effective process option. Air stripping also generates VOC-laden air emissions, which may require further treatment (see Vapor Phase Carbon Adsorption evaluation in this section).

Implementability. Air stripping is readily implementable for the treatment of Site groundwater using commercially available equipment and conventional installation methods. The construction of a treatment system in the wetlands area will have to comply with location specific ARARs such as the Protection of Wetland (Executive Order 11990) (**Appendix B Table B-2**).

Cost. The capital and O&M costs for air stripping, including pre-treatment (filtration, etc.) and post-treatment (vapor treatment), are high when compared to other ex-situ groundwater treatment process options.

Conclusion. Although air stripping is a potentially effective process for treatment of VOCs in Site groundwater, it has been eliminated from further consideration because other more effective and potentially less expensive options are available that provide a similar or higher level of treatment.

3.2.2.5.2 Carbon Adsorption

This process involves the removal of dissolved organic COCs from groundwater by adsorption onto granular activated carbon. Contaminated groundwater is typically pumped through a vessel containing the carbon. COCs are not destroyed by this process, but are physically separated and transferred to the carbon. Granular activated carbon is an excellent sorbent due to its large surface area, which generally ranges from 500 to 2,000 square meters per gram (m^2/g). Carbon adsorption can be used as a primary treatment process for VOC removal, or as a "polishing" treatment step following a primary treatment process (e.g., air stripping). The tendency for adsorption onto carbon is dependant upon a number of physical factors including the type of COC. After exhaustion, spent carbon from groundwater treatment is typically thermally reactivated or incinerated offsite.

Effectiveness. Carbon adsorption is a well developed, widely used process for removal of most dissolved VOCs including those present in the Site groundwater. Carbon adsorption is considered by USEPA to be a "presumptive technology" for ex-situ treatment of dissolved organic VOCs under the Superfund Accelerated Clean-up Model. The presence of other chemicals in groundwater, such as iron, can adversely impact process performance.

Implementability. Carbon adsorption could be readily implemented for the treatment of Site groundwater using commercially available equipment and conventional installation methods. Pilot testing is warranted to evaluate removal efficiencies and other design information. Planning for the reactivation or disposal of spent carbon must be considered as part of implementation. Offsite reactivation and/or disposal may require handling the spent carbon as a hazardous waste. The construction of a treatment system in the wetlands area will have to comply with location specific ARARs such as the Protection of Wetland (Executive Order 11990) (**Appendix B Table B-2**).

Cost. Capital costs for carbon adsorption are moderate, and O&M costs are low to moderate depending on the frequency of carbon bed change outs. These factors are in turn dependent on whether the carbon is used for primary (moderate O&M cost) or secondary/polishing (low O&M costs) treatment.

Conclusion. Carbon adsorption is an effective, readily implemented process for VOC treatment, and it is therefore retained as a potential component of groundwater treatment alternatives within the alluvium.

3.2.2.5.3 Chemical Oxidation

This process involves the addition of chemical oxidizing agents to a waste stream to convert organic COCs, including VOCs and SVOCs into innocuous end products such as carbon dioxide, water, and chloride ions (in the case of chlorinated organic compounds). Chemical oxidation can also be used to precipitate certain metals, such as iron. Commonly used oxidizing agents include ozone, hydrogen peroxide, sodium hypochlorite, and potassium permanganate. Ozone and hydrogen peroxide are typically preferred for organics destruction in groundwater because chlorine-based oxidants can produce hazardous by-products, such as trihalomethanes and hydrogen chloride gas, and tend to produce residual chlorine concentrations.

Effectiveness. Chemical oxidation is a potentially effective method for both the destruction of dissolved organic COCs and the precipitation of iron, which is present in Site groundwater. Chemical oxidation is considered by USEPA to be a "presumptive technology" for ex-situ treatment of dissolved organic COCs under the Superfund Accelerated Clean-up Model. This process is not in common use for groundwater treatment applications.

Implementability. Chemical oxidation is readily implemented for the treatment of Site groundwater using commercially available equipment and conventional installation methods. Treatability and/or pilot testing are warranted to finalize design considerations, including an evaluation to determine the type of oxidizing agent most effective for impacted groundwater at the Site. This process would likely generate sludge from the precipitation of iron and manganese. Sludge may be hazardous and require appropriate treatment/disposal at an offsite RCRA-permitted facility. The construction of a treatment system in the wetlands area will have to comply with location specific ARARs such as the Protection of Wetland (Executive Order 11990) (**Appendix B Table B-2**).

Cost. The capital cost for chemical oxidation is considered moderate, and O&M costs are considered moderate to high as a result of the likely need to process and dispose of sludge generated from the precipitation of iron.

Conclusion. Although chemical oxidation is a potentially effective process for the treatment of COCs in Site groundwater, it has been eliminated from further consideration because of a limited record of accomplishment in groundwater treatment applications as compared to other COC removal processes; and increased cost compared to other ex-situ treatment options.

3.2.2.5.4 Advanced Oxidation

Advanced oxidation combines the use of strong oxidizing agents, such as ozone and hydrogen peroxide; *with ultraviolet light to facilitate faster and more complete destruction of dissolved* organic compounds than obtained by chemical oxidants alone. Ozone and hydrogen peroxide are converted to very reactive hydroxyl radicals through a photolytic reaction. The hydroxyl radicals oxidize organic and inorganic constituents, ultimately breaking down the organics into carbon dioxide, water, and residual chloride ions (in the case of chlorinated organics). Inorganic constituents, such as iron and manganese, are also oxidized and precipitated, potentially resulting in the fouling of UV lamps and loss of treatment efficiency.

Effectiveness. Advanced oxidation is a well-developed, increasingly used process, which has proven effective for destruction of many of the VOCs present in Site groundwater. As a destruction process, it is advantageous in that it does not transfer COCs to another medium. Advanced oxidation is considered by USEPA to be a "presumptive technology" for ex-situ treatment of dissolved organic VOCs under the Superfund Accelerated Clean-up Model.

Implementability. Advanced oxidation is readily implemented for treatment of Site groundwater using commercially available equipment from a limited number of vendors. Treatability and/or pilot testing are warranted to assist in evaluating pre-treatment requirements and obtain design information. The construction of a treatment system in the wetlands area will have to comply with location specific ARARs such as the Protection of Wetland (Executive Order 11990) (**Appendix B Table B-2**).

Cost. The capital and O&M costs for advanced oxidation are considered high compared to other COC treatment processes.

Conclusion. Although advanced oxidation is a potentially effective process for treatment of organics in Site groundwater, it has been eliminated from further consideration because other potentially less expensive options are available that provide a similar or higher level of treatment.

3.2.2.6 Discharge

The following groundwater discharge process options were retained in the screening step for COC impacted groundwater within the alluvium:

Remedial Technology	Process Option
Direct Discharge	Surface Discharge
	Discharge To Publicly-Owned Treatment Works (POTW)

3.2.2.6.1 Surface Discharge

Surface discharge refers to the direct discharge of treated groundwater to the Wetland Creek. The Wetland Creek, which flows south of the Property, originates at an impound lake located approximately 0.3 miles west of the Property, flows southeast for approximately 0.36 miles, crosses US Highway 61 and then follows an engineered course across the flat valley bottom to the southeast of the Property, before discharging into the Cape LaCroix Creek.

Effectiveness. Discharge to the Wetland Creek is an effective means of final disposition of the volume of water expected to be generated by groundwater collection and treatment.

Implementability. The implementability of this method would depend on WQS for the Wetland Creek, and whether the treatment system can achieve those standards. Although an actual discharge permit may not be necessary under CERCLA, the substantive requirements of the National Pollution Discharge Elimination System (NPDES) permit program and MDNR WQS would have to be considered.

Cost. The capital and O&M costs for surface discharge of treated groundwater to the Wetland Creek are considered moderate when compared to other discharge options.

Conclusion. Direct discharge of treated groundwater to the Wetland Creek is retained as a potential component of Site groundwater remedial alternatives.

3.2.2.6.2 Discharge To Publicly Owned Treatment Works (POTW)

Discharge to POTW refers to discharge to the Cape Girardeau POTW. Discharge to the POTW would require either boring under US Highway 61 to connect to the existing sewer main or extending the sewer connection to the wetland area. For either option all City, County, and State specifications will need to be met.

Effectiveness. Discharge to POTW is an effective means of final disposition of the volume of water expected to be generated by groundwater collection and treatment.

Implementability. The implementability of this method would depend on the sewer discharge permit requirements. Although an actual discharge permit may not be necessary under CERCLA, the substantive requirements of the POTW and MDNR would have to be considered. Discharge to the POTW might require crossing public and/or private property, and obtaining rights-of-way for a discharge pipeline.

Cost. The capital and O&M costs for discharge of treated groundwater to POTW are considered moderate compared to other discharge options.

Conclusion. Discharge to the POTW is retained as a potential component of Site groundwater remedial alternatives.

3.2.2.7 In-Situ Treatment

The following in-situ treatment process options were retained in the screening step for COC impacted groundwater within the alluvium:

Remedial Technology	Process Option
In-Situ Treatment	Enhanced Biodegradation (EBD)
	Monitored Natural Attenuation (MNA)
	Permeable Reactive Barriers

3.2.2.7.1 Enhanced Bio-Degradation (EBD)

The enhanced biological degradation (EBD) of chlorinated VOCs is an accepted viable groundwater remediation process. Various enhancements are available to stimulate biological activity and accelerate the degradation process, including the injection of hydrogen release compound (HRC®) which is an example of this EBD process option. HRC®, a viscous, honey-like substance, is injected into groundwater, which slowly releases lactic acid. Naturally occurring anaerobic microbes metabolize the lactic acid to produce hydrogen. The hydrogen, in turn, is used by other indigenous microbes to break down target chemicals. This occurs through a stepwise process, which produces harmless end-products such as ethene and ethane.

Effectiveness. Applying EBD to the subsurface for effective remediation can be difficult and uncertain. The effectiveness of EBD to stimulate biological activity and accelerate the degradation process depends on the suitability of the Site's geochemical/biological condition for biodegradation of chlorinated VOCs. Additionally, since the source location of discharge of COCs to the alluvium groundwater at depth from the bedrock is unknown, this process option will require further investigation to identify appropriate application locations.

Implementability. EBD can be readily implemented for COC impacted alluvium groundwater using conventional equipment and resources. Treatability and/or pilot testing are warranted to finalize design considerations, including an initial evaluation to determine the geochemical conditions at the Site.

Cost. The capital and O&M costs for EBD are considered moderate compared to other in-situ groundwater treatment options.

Conclusion. EBD is retained as a possible component of groundwater remedial action alternatives for the COC impacted groundwater within the alluvium.

3.2.2.7.2 Monitored Natural Attenuation (MNA)

Although this process is categorized under the heading of "In-situ Biological Treatment" (FRTR, 1997), natural attenuation refers to a variety of physical, chemical, as well as biological mechanisms, which act to reduce the mobility, toxicity, and/or mass of COCs in groundwater. These mechanisms include dilution, dispersion, adsorption, chemical reaction/fixation, volatilization, and biodegradation. "Monitored" natural attenuation (MNA) refers to ongoing monitoring of groundwater to evaluate conditions and verify/confirm that natural processes are occurring and will achieve TCLs in a reasonable time frame.

Effectiveness. The effectiveness of MNA processes, acting independently or in combination with other process options, to achieve the RAOs for the alluvium impacted groundwater plume, in a reasonable time frame (30 years), will require further investigation in accordance with the criteria set forth in the USEPA guidance (USEPA, 1997).

Implementability. MNA can be readily implemented for COC impacted alluvium groundwater using conventional equipment, resources, and monitoring techniques. The process, however, has only recently been recognized as potentially viable as part of a remedial alternative selection. To establish the viability of using MNA as an appropriate process option will require collation and assessment of data to meet the OSWER selection criteria (USEPA, 1997), and performance monitoring to evaluate remedy effectiveness and to ensure protection of human health and the environment.

Cost. The capital and O&M costs for MNA are considered low to moderate compared to other in-situ groundwater treatment options.

Conclusion. MNA is retained as a possible component of groundwater remedial action alternatives for the COC impacted alluvium.

3.2.2.7.3 Permeable Reactive Barriers

Permeable reactive barriers are installed across the flow path of a contaminant plume, allowing the COC impacted groundwater plume to passively move through the barrier. The barriers can be installed within trenches or for deeper applications through the injection of chemicals under pressure into closely spaced boreholes. The barriers allow the passage of water while prohibiting the movement of COCs by employing agents such as zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, microbes, oxidants or reductant chemicals. Within the permeable reactive barrier, COCs will either be degraded or retained in a concentrated form by the barrier material. The selection of reactive media will be the subject of detailed laboratory and field testing to ensure effectiveness.

Effectiveness. Permeable reactive barriers are a potentially effective method for the destruction or retention of dissolved organic COCs, although the effectiveness of permeable reactive barriers may reduce over time. The reduction in effectiveness could result from biological activity or chemical precipitation, which may limit the permeability of the barrier and therefore require the replacement of the reactive media. Treatability and/or pilot testing are warranted to finalize design considerations including an evaluation to determine the type of reactive media most effective for impacted groundwater at the Site. Working with heavy equipment results in additional human health risks during the installation period and may cause disruption/damage to the wetlands area.

Implementability. In this case, given the depths of COC impacted alluvial groundwater (in excess of 69 feet), the use of boreholes is considered to provide an advantage over trench installed permeable reactive barriers. Injection boreholes are commonly advanced in two parallel rows across the COC impacted groundwater plume, and for silts and clays, spaced approximately 5 feet to 10 feet apart. Commercially available equipment can be used to advance the boreholes, although measures may be required to limit the impact of heavy equipment on the wetland area.

Cost. The capital cost for permeable reactive barriers is considered high, and O&M costs are considered moderate to high as a result of the likely need to periodically replace the reactive media.

Conclusion. Although permeable reactive barriers have the potential to be effective for treatment of organics in Site groundwater, permeable reactive barriers has been eliminated from further consideration because of concerns regarding their long term effectiveness, difficulties in implementation and high cost.

3.2.2.8 Summary of Selected Technologies and Process Options

On the basis of screening and evaluation of technologies and process options discussed herein and summarized in **Table 3.4**, remedial action alternatives for COC impacted groundwater within the alluvium will be assembled from the following:

General Response Action	Remedial Technology	Process Option
No Action	Not Applicable	Not Applicable
Limited Action	Institutional Controls	Land and Resource Use Restrictions
	Wellhead Treatment	Wellhead Treatment Systems
	Long-Term Monitoring	Groundwater Monitoring
Collection	Extraction (Groundwater Pumping)	Vertical-Drilled Extraction Wells
Ex-Situ Treatment	Physical Treatment	Carbon Adsorption
Discharge	Direct Discharge	Surface Discharge
		Discharge To Publicly-Owned Treatment Works (POTW)
In-Situ Treatment	In-Situ Treatment	EBD
		Monitored Natural Attenuation (MNA)

The implementation of the retained process options on their own, as remedial action responses, will not meet all the Site RAOs. However, combinations of the retained process options are expected to meet the Site RAOs.

4 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

This section presents the formulation and description of a range of remedial action alternatives. In assembling GRAs into remedial action alternatives, technologies and process options retained from **Section 3.0** are combined to form remedial action alternatives for COC impacted groundwater within the fractured bedrock and the alluvium. The alternatives described in this section represent various conceptual approaches to addressing Site COCs. The alternatives are subject to detailed analysis in **Section 5.0**.

Remedial alternatives developed for the Site are categorized into Fractured Bedrock (FB) and Alluvium (AL) alternative groups. The FB group addresses groundwater contamination within the fractured bedrock and the AL group is focused on groundwater within the alluvium. The alternatives within each group provide various degrees of risk reduction via different levels and/or methods of remediation, ranging from no action, to limited action, to a number of treatment/removal alternatives which vary in the degree to which the toxicity, mobility, or volume of contaminants and wastes are reduced.

The Fractured Bedrock Alternatives proposed for the Site include:

- FB-1: No Action; and,
- FB-2: Institutional Controls/Wellhead Treatment/ Long Term Monitoring.

The Alluvium Alternatives for the Site include:

- AL-1: No Action;
- AL-2: Institutional Controls/Wellhead Treatment/Long-Term Monitoring;
- AL-3 Groundwater Collection, Ex-Situ Treatment and Discharge;
- AL-4 EBD; and,
- AL-5 Monitored Natural Attenuation.

4.1 FB ALTERNATIVE DESCRIPTIONS

The groundwater alternatives for the fractured bedrock have been developed from the process options evaluated in **Section 3.2** as summarized in **Section 3.2.1.8.**

The Fractured Bedrock Alternatives proposed for the Site include:

- FB-1: No Action; and,
- FB-2: Institutional Controls/Wellhead Treatment/ Long Term Monitoring.

Detailed descriptions of the Fractured Bedrock Alternatives are provided in the following sub-sections.

4.1.1 ALTERNATIVE FB-1: NO ACTION

Alternative FB-1, the "No Action" alternative, can be applied to COC impacted groundwater in the fractured bedrock. The No Action alternative is developed and evaluated for baseline comparison purposes as described in the NCP under Section 300.68. This alternative is proposed as a means of identifying the problems posed by the Site if no remedial actions are implemented to address groundwater contamination.

4.1.2 ALTERNATIVE FB-2: INSTITUTIONAL CONTROLS/WELLHEAD TREATMENT/ LONG TERM MONITORING

Alternative FB-2 incorporates all of the Limited Action process options retained from **Section 3.3.1.2.** The retained process options are ICs, wellhead treatment units, and groundwater monitoring. The specific components of Alternative FB-2 are as follows:

4.1.2.1 Institutional Controls

Institutional controls will be implemented in layers as appropriate to enhance the protectiveness of the remedy. The primary form of institutional control for the Property is expected to be a proprietary control, specifically a restrictive covenant and grant of access. This form of proprietary control was selected as it is effective as an informational device and creates a readily enforceable legal property interest. For areas where COCs are present off the Property, this proprietary control may also be effective; however, a special area designation or other techniques may also be appropriate.

The imposition of a restrictive covenant and grant of access on the Property will be sought. The grantee of this restrictive covenant will have the right of access and the authority to enforce the restrictive covenant. The EPA may be named as a third-party, or intended, beneficiary in this instrument so that EPA may also have the ability to enforce the terms of the restrictive covenant and grant of access.

This restrictive covenant and grant of access will be patterned on either the: 1) Model Restrictive Covenant and Grant of Access found in the MDNR CALM Appendix E, Attachment E1; 2) the proposed Model Declaration of Restrictive Covenant and Grant of Access which is anticipated to be located in the MDNR Long-term Stewardship for Risk-based Corrective Action Sites, Appendix J, Technical Guidance; or, 3) other appropriate instruments.

The objectives of imposing a restrictive covenant and grant of access on this Site are to eliminate or minimize exposures to contamination remaining at the Site and limit the possibility of the spread of contamination. These objectives will be achieved by use of the restrictive covenant and grant of access as it will: 1) provide notice; 2) limit use; and 3) provide for all required access.

Specifically, the restrictive covenant and easement will achieve this by:

- providing notice to prospective purchasers and occupants that there are contaminants in the groundwater.
- ensuring that future owners are aware of engineered controls (if any) put into place as part of this remedial action.
- prohibiting residential, commercial and industrial uses, except those uses which would be consistent with the remedial action.
- prohibiting or restricting the placement of groundwater wells.
- prohibiting other ground penetrating activities which may result in the creation of a hydraulic conduit between water bearing zones.
- providing access to USEPA and the State of Missouri for verifying land use.
- prescribing actions that must be taken to install and/or maintain engineered controls (if applicable).
- providing access to USEPA and the State of Missouri for sampling and the maintenance of engineered controls (if applicable).

In addition to the above proprietary control, MDNR Geological Survey & Resource Assessment Division may designate the impacted areas associated with the MEW Site as a "special area" as provided for in the Well Driller's Act, RSMo 256.606. Special areas are geographic regions that are subject to stringent well-drilling requirements due to special circumstances, such as the presence of groundwater contamination. Such a designation would require rulemaking, and, if established, would require all well installation contractors to follow new drilling standards for well construction in the contaminated area.

Other ICs may include but are not limited to: ordinances; inspection regimes; property notices; and public information.

4.1.2.2 Wellhead Treatment Systems

Wellhead treatment systems could be installed and maintained for any existing potable water supply well in the event that one becomes impacted by COCs, or new potable water supply wells are installed where extracted groundwater could be reasonably expected to have COC concentrations greater than TCLs. To address an unconfirmed potential future need, the installation and maintenance of a wellhead treatment system at one water supply well in the future is contemplated under this alternative. Wellhead treatment consists of treatment systems, such as activated carbon/air strippers, to remove VOCs from groundwater pumped for potable use. Ongoing maintenance of wellhead treatment systems would include periodic change out of spent carbon, as well as, other adjustments/repairs necessary to maintain proper function of the systems.

Assuming that a future wellhead treatment system is necessary where extracted groundwater could be reasonably expected to have COC concentrations greater than TCLs, the process for well installation and operation would be the subject of a detailed design and the formation of an operation and maintenance report.

Wellhead treatment is considered a future process option that may or may not be required. Given the uncertainty regarding the future need for this process option, this has been excluded from the cost estimate for alternative FB-2.

4.1.2.3 Groundwater Monitoring

Groundwater monitoring could involve sampling and laboratory analysis of COC impacted groundwater from the 14 existing monitoring wells installed within the bedrock (**Figure 1.2**). The subset of 14 wells is consistent with the bedrock monitoring wells sampled by Komex in the November 2004 sampling event. Laboratory analysis of groundwater samples for VOCs, SVOCs, and PCBs is proposed under this monitoring program.

Annual maintenance of monitoring wells, such as repair of damaged well caps or concrete surface seals would also be a necessary component of groundwater monitoring. Following the achievement of Site RAOs or upon determination that monitoring is no longer necessary, abandonment/decommissioning of Site groundwater monitoring wells will be required. Monitoring well abandonment would be carried out in accordance with MDNR's requirements.

4.1.2.4 Review of Site Conditions and Risks Every Five Years

Review of Site conditions and risks is conducted by the USEPA at five-year intervals and documented in a report. The review is carried out pursuant to a statutory requirement of CERCLA and the NCP that applies to remedial actions in which COCs remain onsite (CERCLA Section 121 (c) and the NCP: 40 C.F.R. 300.430(f)(4)(ii)).

4.2 AL ALTERNATIVE DESCRIPTIONS

The groundwater alternatives for the alluvium have been developed from the process options evaluated in **Section 3.3** as summarized in **Section 3.3.1.8**.

The Alluvium Alternatives for the Site include:

- AL-1: No Action;
- AL-2: Institutional Controls/Wellhead Treatment/ Long Term Monitoring;
- AL-3 Targeted Groundwater Collection, Ex-Situ Treatment and Discharge;
- AL-4 EBD; and
- AL-5 Monitored Natural Attenuation

Detailed descriptions of the Alluvium Alternatives are provided in the following sub-sections. Alternatives AL-1 and AL-2 are identical to Alternatives FB-1 and FB-2, respectively, with the exception of the type (bedrock vs. alluvium) and number of wells proposed for monitoring. The number of water samples, sampling frequency, and analytical parameters will be based on discussions with the USEPA. For a description of Alternatives AL-1 and AL-2, please refer to **Sections 4.1.1.1** and **4.1.1.2**, respectively

4.2.1 ALTERNATIVE AL-3: TARGETED GROUNDWATER COLLECTION, EX-SITU TREATMENT, AND DISCHARGE

Alternative AL-3 includes all of the measures proposed under AL-2, to achieve the Site RAOs, plus targeted groundwater collection, treatment and discharge (pump and treat) within the alluvium. The objective of the targeted pump and treat system is to create a capture zone that encompasses the COC impacted alluvium groundwater, thus providing containment for the impacted groundwater plume.

This section describes the conceptual approach and assumptions associated with groundwater collection and treatment for remediation of alluvial groundwater. The conceptual design of the extraction well locations and pumping rates discussed below was developed in part based on potential site-related impacts in the alluvium associated with wells MW-16B and MW-16C. The groundwater treatment system conceptual design was based on technology performance data, treatment equipment vendor information, and design parameters reported in the literature. An itemized cost estimate for Alternative AL-3 is presented in **Appendix D.**

4.2.1.1 Pre-Design Investigations

Pre-design investigations focused on aquifer hydrogeologic properties and groundwater treatability would be necessary to design the groundwater collection and treatment system contemplated as part of this alternative. Aquifer pumping test(s) would be implemented to obtain data (e.g., hydraulic conductivity, specific yield, specific capacity, extent of groundwater capture) relevant to selection of extraction well design parameters, such as the number of wells, their locations and pumping rates necessary to achieve COC impacted alluvium groundwater plume capture. Groundwater treatability testing would be conducted concurrent with aquifer testing to characterize extracted groundwater quality, evaluate the effectiveness of proposed treatment processes and assist in the final selection and sizing of treatment equipment.

4.2.1.2 Conceptual Design of Groundwater Collection, Treatment and Discharge System

The proposed conceptual design for the groundwater collection, treatment and discharge system would consist of the following principal subsystems:

- Groundwater Extraction System;
- Groundwater Treatment System; and
- Treated Groundwater Discharge System.

4.2.1.2.1 Groundwater Extraction System

The groundwater extraction system conceptual design is based on the general conceptual model of COCs discharging from the bedrock into the alluvium at depth and has been designed considering COC impacts at wells MW-16B and MW-16C. It should be emphasized that the final design of the extraction well system, including the number of wells, well layout, screened intervals, and extraction rates should be based on the results of aquifer testing conducted as part of pre-design investigations. Nevertheless, it is a requirement of the FS to estimate the approximate number of wells and the likely pumping rate in order to evaluate and estimate the remedial alternative's cost.

The minimum number of wells and pumping rates required to achieve containment of the COC impacted alluvium groundwater plume were estimated based upon analytical and field data collected as part of the Site characterization and groundwater monitoring activities. The maximum concentration of TCE in the alluvium have been detected at concentrations of 9.2 ug/L and 9.9 ug/L in samples from monitoring wells MW-16B and MW-16C, respectively. The average hydraulic conductivity for the alluvium was estimated as 19.7 feet/day (Komex, 2004). Based on monitoring and slug test data, a reasonable individual extraction well pumping rate was estimated as approximately 10 gpm. The capture zone was calculated based upon the estimated aquifer thickness (80 feet), hydraulic conductivity (19.7 feet/day), hydraulic gradient (pre-pumping [0.0014 feet/feet]) and assumed pumping rate (10 gpm [1,925 cubic feet per day]). Conservative predicted capture zones for the proposed wells are presented in **Figure 4.1**.

For the purposes of the FS, we assume that four wells would be required to create a capture zone that encompasses the location where the highest COC concentrations were detected in the alluvium. Given the individual extraction well pumping rates, a total combined extraction well pumping rate is therefore estimated at 40 gpm. The proposed extraction well layout is shown on **Figure 4.1**.

The groundwater extraction wells would typically be constructed of 4-inch diameter PVC well casing, screened from approximately 50 to 100 feet bgs or to the clay/ alluvium interface, (whatever is deeper). Final design of the extraction well system, including the number of wells, well layout, screened intervals, and extraction rates should be based on the results of aquifer testing conducted as part of pre-design investigations.

Each extraction well would be equipped with an electrical submersible pump and instrumentation, such as a pressure gauge, water level transducer, and flow meter. The wellheads would be completed in a below grade vault or above grade enclosure. The extraction wells would be plumbed to the groundwater treatment system via two-inch diameter underground piping.

4.2.1.2.2 Groundwater Treatment System

The purpose of the groundwater treatment system is to reduce contaminant concentrations in the extracted groundwater to levels suitable for discharge. The conceptual design proposed herein conservatively assumes that carbon adsorption will be selected.

Primary factors influencing groundwater treatment process design are flow rate and influent concentrations (i.e., the concentration of COCs in the extracted groundwater). Under this alternative the groundwater treatment system would be sized to treat a maximum flow rate of 50 gpm. The anticipated influent concentrations were assumed to be the maximum contaminant concentrations, including non-detectable values, associated with groundwater monitoring well sampling and laboratory analysis undertaken as part of the Site characterization. COC concentrations are presented in **Table 2.1** and provide the basis for costing the groundwater treatment process and components discussed in more detail below. Final selection of design flow rate and influent concentrations should consider data collected as part of pre-design investigations.

In concept, extracted groundwater would enter a 2,500-gallon equalization tank as the first step in the groundwater treatment process. The equalization tank provides storage to dampen variations in well pumping rates and contaminant concentrations entering the system. Groundwater will then be pumped through a carbon adsorption system, which may or may not include a pre-treatment component (suspended solids filtration). The objective of the carbon adsorption system would be to reduce the levels of COCs in the extracted groundwater to concentrations equal to or below levels suitable for discharge. The carbon adsorption treatment system would consist of a transfer pump and three, 3,000-pound granular activated carbon vessels connected in series. Treatability testing should be performed as part of pre-design investigations to develop parameters for final design of the carbon adsorption system.

4.2.1.2.3 Treated Groundwater Discharge System

Treated groundwater would be discharged either to the Wetland Creek or to the POTW. Final selection of a discharge option will occur as part of final design and will depend, in part, on the discharge concentration limits established for each method. The conceptual design proposed herein assumes that discharge to the POTW will be selected.

4.2.2 ALTERNATIVE AL-4: EBD

Alternative AL-4 includes all of the measures proposed under AL-2 plus EBD. For purposes of costing, the EBD for this FS incorporates HRC injection to achieve the Site RAOs. The objective of injecting HRC into the aquifer is to stimulate biological activity and to accelerate the dehalogenation process of chlorinated COCs in alluvial groundwater. The treatment approach at the Site will consist of a barrier design approach. This treatment strategy should reduce the risk associated with the downgradient migration of COCs at targeted areas within the alluvium.

The effectiveness of HRC injection to stimulate biological activity and accelerate the dehalogenation process depends on the suitability of the Site's geochemical and biological conditions for biodegradation of chlorinated VOCs. Treatability and/or pilot testing are warranted to finalize design considerations, including an initial evaluation to determine the geochemical and biological conditions at the Site.

For the purposes of the FS, we assume that five 2-inch wells will be installed in a row upgradient of monitoring wells MW-16B and MW-16C. The wells will be spaced approximately 10 feet apart and will be located perpendicular to the groundwater flow direction in the alluvium. The proposed extraction well layout is shown on **Figure 4.2**. These wells will be used to inject HRC into the aquifer. HRC is consumed during the dehalogentaion process, therefore, it must be replenished for the chlorinated COC remediation to continue.

4.2.3 ALTERNATIVE AL-5: MONITORED NATURAL ATTENUATION

Alternative AL-5 includes all of the measures proposed under AL-2, plus MNA to achieve the Site RAOs. To establish the viability of using MNA as a remedial alternative will require collation and assessment of data to meet the OSWER selection criteria (USEPA, 1997), and performance monitoring to evaluate remedy effectiveness and to ensure protection of human health and the environment.

Under this alternative, monitoring to assess natural attenuation would be required for a period of no less than one year to evaluate the feasibility of this alternative. Data collected during this year would be required to demonstrate at a minimum two of three lines of evidence to support MNA as an effective process. These lines of evidence include:

- Primary line - Data from historical groundwater samples demonstrating a trend of declining contaminant mass;
- Secondary line - Indirect demonstration of natural attenuation processes through assessment of related parameters (dissolved oxygen, nitrate, iron (II), sulfate, methane etc.); and

- Tertiary line - data from field or microcosm studies that demonstrate biological activity in the groundwater.

5 DETAILED ANALYSIS OF ALTERNATIVES

The remedial alternatives assembled and described in **Section 4.0** are analyzed in detail in this section. The detailed analysis of alternatives is intended to provide sufficient information to compare the alternatives and facilitate selection of a specific remedy for the fractured bedrock and alluvium. The analysis focuses on the NCP set of nine evaluation criteria, which encompass statutory requirements, as well as technical, cost, and institutional considerations, which are considered appropriate for a thorough evaluation.

After the alternatives have been assessed against the evaluation criteria, a comparative analysis is conducted to evaluate the relative performance of each alternative in relation to each specific criterion. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative so that key tradeoffs can be identified.

Descriptions of the nine evaluation criteria are presented in **Section 5.1**. A detailed analysis of the remedial alternatives is presented in **Section 5.2**. The comparative analysis is presented in **Section 5.3**.

5.1 CRITERIA FOR EVALUATION OF ALTERNATIVES

Nine evaluation criteria have been developed to provide the basis for conducting the detailed analysis of remedial alternatives and for subsequently selecting an appropriate remedial action alternative. The criteria are prescribed in the NCP under Section 300.430 (e) 9 (iii) and further described in the USEPA guidance document (USEPA, 1988a). The nine evaluation criteria are:

- Overall Protection of Human Health and the Environment;
- Compliance with ARARs;
- Long-term Effectiveness and Permanence;
- Reduction of Toxicity, Mobility, and/or Volume through Treatment;
- Short-term Effectiveness;
- Implementability;
- Cost;
- State Acceptance; and
- Community Acceptance.

The first two criteria listed above (i.e., overall protection of human health and the environment, and compliance with ARARs) are "threshold" criteria in that they relate directly to statutory findings that must ultimately be made in the decision document, and therefore they must be satisfied in order for an alternative to be selected. The next five criteria represent the primary "balancing" criteria upon which the comparative analysis of alternatives is based. The final two evaluation criteria: State acceptance and community acceptance, represent modifying criteria, which will be considered in the comparative analysis of alternatives and fully assessed following public comment on the FS Report and the proposed plan. Brief descriptions of the evaluation criteria are provided below:

5.1.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This criterion assesses whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the evaluations of long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Protectiveness focuses on how site risks are reduced or eliminated by each alternative. Risk reductions are associated with how effectively an alternative meets the RAOs. This criterion is considered a threshold and must be met by the selected alternative.

5.1.2 COMPLIANCE WITH ARARS

This criterion is used to evaluate whether each alternative will meet all identified Federal and State ARARs, or whether justification exists for waiving one or more ARARs. The detailed analysis will describe how each alternative will meet these requirements. This criterion is also a threshold that must be met by the selected alternative unless an ARAR is waived. ARARs are identified in **Appendix B**. **Section 2.1** provides a summary of the ARARs evaluation.

5.1.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Each alternative is evaluated in terms of risk remaining at the site after RAOs have been met. The primary focus of this evaluation is the extent and effectiveness of controls used to manage the risk posed by treatment of residuals or untreated wastes. The following criteria are considered:

- Adequacy of mitigation controls;
- Reliability of mitigation controls; and
- Magnitude of residual risk.

5.1.4 REDUCTION OF TOXICITY, MOBILITY, AND/OR VOLUME THROUGH TREATMENT

This criterion addresses the statutory preference for the selection of alternatives, which utilize treatment technologies that permanently and significantly reduce toxicity, mobility, and/or volume of the Site COCs. This evaluation focuses on the following specific factors:

- The treatment process(es) utilized and the materials they would treat;
- The amount of hazardous materials or contaminated groundwater that would be destroyed or treated;
- The degree of anticipated reduction in toxicity, mobility, and/or volume;
- The degree to which the treatment would be permanent and irreversible;
- The type and quantity of treatment residuals that would remain; and
- Whether the alternative would satisfy the statutory preference for treatment as a primary element of the alternative.

5.1.5 SHORT-TERM EFFECTIVENESS

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase. Under this criterion, alternatives are evaluated with respect to their effects on human health and the environment during remedial action implementation. The following factors are considered:

- Exposure of the community during implementation;
- Exposure of the workers during construction;
- Environmental impacts; and
- Time required achieving RAOs.

5.1.6 IMPLEMENTABILITY

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The following factors are considered:

- Ability to construct the technology;
- Reliability of the technology;
- Monitoring considerations;
- Availability of equipment and specialists; and
- Ability to obtain approvals from regulatory agencies.

5.1.7 COST

The final balancing criterion considers relative cost estimates for each alternative. The cost estimates are preliminary engineer's estimates and represent opinions of the costs associated with implementing each alternative, and are not equivalent to an estimate that a remedial contractor would bid or professional cost estimator may provide after remedial design is completed and construction documents, if warranted, are prepared. Consistent with USEPA guidance (USEPA, 1988a), the cost estimates attempt to achieve an accuracy of +50% to -30% and include the following:

- Capital costs, including both direct and indirect costs;
- Annual O&M costs, including long-term effectiveness monitoring cost;
- Periodic cost, including data collection and analyses to support the USEPA in its preparation of the Five-Year Review Report ; and
- Net present worth of capital, O&M, and periodic costs.

Direct costs include the purchase of equipment, labor, and materials necessary to install the alternative. Indirect costs include those for engineering, financial, and other services, such as testing and monitoring. Annual O&M costs for each alternative include maintenance materials, labor, and auxiliary materials, as well as operating costs.

The cumulative net present value of each alternative provides the basis for the cost comparison. The cumulative net present value presents the amount of money that, if invested in the initial year of the remedial action at a given rate, would provide the funds required to make future payments to cover all costs associated with the remedial action over its planned life. The cost estimates of the remedial alternatives were developed using Remedial Action Cost Engineering and Requirements (RACER) software (EarthTech, 2003). The present value analysis is performed on all remedial alternatives using a 5.0% initial discount (interest) rate (for years 1 through 15) and 4.0% for Years 16 through 30, and a 3.0% rate of inflation applied over a period of 30 years. **Appendix D** contains spreadsheets showing each component of the cumulative net present value costs.

5.1.8 STATE ACCEPTANCE

Technical or administrative issues and concerns the State of Missouri may have regarding each alternative are considered, including the identification of ARARs, or the proposed use of ICs. The RI/FS has been conducted pursuant to the terms of the Consent Degree to which the USEPA and the MDNR are parties. These parties have provided input to the FS process on an ongoing basis. Specific State concerns not incorporated into the FS Report may be discussed in the proposed plan to be issued for public comment, as detailed in 40 CFR 300.43(e)(iii)(H). As such, this criterion will not be included in the detailed evaluation presented herein.

5.1.9 COMMUNITY ACCEPTANCE

Public concerns, after comments on the RI (Komex 2005d) and FS report, and Proposed Plan are received, will be addressed after the public comment period, and will be incorporated into a "Responsiveness Summary". As such, additional discussion regarding community acceptance is not presented herein.

5.2 DETAILED ANALYSIS OF ALTERNATIVES

The analysis of the Fractured Bedrock and Alluvium Alternatives with respect to the above criteria is presented in the following sections.

5.2.1 ALTERNATIVES FB-1 AND AL-1: NO ACTION

Alternatives FB-1 and AL-1, the No Action alternatives, are intended to provide a baseline against which other alternatives can be compared, as required by the NCP under Section 300.68. Under the "No Action" alternatives, no action would be taken to alter conditions at the Site.

5.2.1.1 Overall Protection of Human Health and the Environment

Alternatives FB-1 and AL-1 are not protective of human health because no action is proposed and the risks posed by the Site under existing conditions, as described in the BHHRA (Komex, 2005f), would continue to be present under these alternatives. With regard to exposure to Site groundwater, risks include exposure of human receptors to COCs through ingestion, inhalation and/or dermal contact with COC impacted groundwater.

5.2.1.2 Compliance with ARARs

Alternatives FB-1 and AL-1 do not address groundwater contamination, and hence, are not compliant with ARARs that regulate groundwater and drinking water quality (e.g., MCLs, State MCLs, and MDNR WQS and GTARCs). Location-specific and action-specific ARARs do not apply to these alternatives because no remedial actions are proposed under Alternatives FB-1 and AL-1.

5.2.1.3 Long-Term Effectiveness and Permanence

Existing residual groundwater contamination at the Site poses unacceptable human health risks under possible future land use scenarios. Under the "No Action" alternatives, the risks would remain unacceptable over the long term. Additional unacceptable risks could occur if incompatible land uses and unanticipated groundwater use as a drinking water supply were allowed. Migration control RAOs would not be met if Alternatives FB-1 and AL-1 are considered the baseline, as COC migration within the fractured bedrock and alluvium would likely continue.

5.2.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Although natural attenuation processes could act to reduce the toxicity or volume of groundwater COCs in both the fractured bedrock and alluvium, Alternatives FB-1 and AL-1 do not propose implementation of a process option to verify this. Alternatives FB-1 and AL-1 do not satisfy the statutory preference for treatment as a principal element.

5.2.1.5 Short-Term Effectiveness

The exposure control RAOs for the Site would not be met if Alternatives FB-1 and AL-1 were considered the baseline.

There are no additional risks to the community and environment posed by Alternatives FB-1 and AL-1 because these alternatives do not include the construction of any CERCLA remedial systems.

5.2.1.6 Implementability

Alternatives FB-1 and AL-1 are readily implemented because no remedial actions are proposed under these alternatives.

5.2.1.7 Cost

There are no costs associated with the implementation of Alternatives FB-1 and AL-1 because no remedial actions are proposed under these alternatives.

5.2.2 ALTERNATIVES FB-2 AND AL-2: INSTITUTIONAL CONTROLS/WELLHEAD TREATMENT/ LONG TERM MONITORING

Alternatives FB-2 and AL-2 rely on ICs, wellhead treatment and long-term monitoring to meet Site RAOs. Under these alternatives, ICs would be established to prohibit/restrict certain Site uses and/or prohibit the use of untreated contaminated groundwater. ICs would be augmented by wellhead treatment at existing potable wells, in the event they become impacted and/or new potable water supply wells are installed in the future. The combination of ICs and wellhead treatment would prevent the use of groundwater containing COCs. Groundwater monitoring will be conducted.

Site-specific information and analysis of these alternatives relative to the nine NCP criteria is provided in the following sections.

5.2.2.1 Overall Protection of Human Health and the Environment

Implementing Alternatives FB-2 and AL-2 at the Site would protect human health over the long term. Protection of human health and the environment would be achieved through a combination of ICs and wellhead treatment. ICs would restrict certain Site and near-Site uses and prohibit the use of untreated COC impacted groundwater for any purpose. ICs would guard against future risks to human health and the environment and exposure control RAOs would be met. In the case where an existing potable well should become impacted, or a new potable water supply well is installed where it could extract groundwater that could reasonably be expected to have COCs at concentrations that exceed the TCLs, a wellhead treatment system would be constructed.

5.2.2.2 Compliance with ARARs

Alternatives FB-2 and AL-2, through ICs, wellhead treatment and long-term monitoring would not be compliant with chemical-specific ARARs that regulate drinking water quality (e.g., MCL, State MCL, and MDNR WQS and GTARCs). It is possible that natural attenuation processes could act to reduce COCs to levels compliant with chemical specific ARARs. However, the timeframe required to achieve compliance could exceed 30 years and possibly 100 years in the fractured bedrock portion of the COC plume. Location-specific and action-specific ARARs do not apply to these alternatives because no intrusive remedial actions are proposed.

5.2.2.3 Long-Term Effectiveness and Permanence

Residual human health risks from COCs in groundwater would remain for an unknown period under Alternatives FB-2 and AL-2, and ICs would be required for an indefinite period to ensure protectiveness. ICs are intended to limit exposure to COC impacted groundwater. These controls coupled with wellhead treatment, are expected to prohibit ingestion of or contact with untreated groundwater for any use over the long term. As such these alternatives will manage the risk posed by the COC impacted groundwater. Alternatives FB-2 and AL-2 are considered effective over the long term.

Groundwater monitoring performed under these alternatives would be effective at providing indications of COC migration within and from the Site.

5.2.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives FB-2 and AL-2 do not act to reduce the toxicity, and/or mass of COCs in groundwater within the fractured bedrock and alluvium. Therefore, Alternatives FB-2 and AL-2 are not considered effective at satisfying this criterion.

5.2.2.5 Short-Term Effectiveness

Alternatives FB-2 and AL-2 require no aboveground treatment (beyond future wellhead treatment), thus minimizing direct worker contact with groundwater. Long-term groundwater monitoring has minimal impact on workers responsible for periodic groundwater sampling and any risks to workers can be controlled and mitigated by implementation of proper health and safety measures in accordance with OSHA 1910.120. COC concentrations in groundwater are anticipated to exceed TCLs for a time scale of greater than 30 years. Alternatives FB-2 and AL-2 are considered to present a minimal short-term effect.

5.2.2.6 Implementability

Alternatives FB-2 and AL-2 are technically and administratively implementable at the Site. ICs that are developed as part of these alternatives may require administrative activity and legal action. ICs may be implemented without significant delays. Long-term monitoring would not interfere with onsite activities nor would it interfere with the implementation of future response actions within the Site. The equipment and services to collect groundwater samples are commercially available. Alternatives FB-2 and AL-2 are easy to implement at the Site.

5.2.2.7 Cost

A range of costs have been prepared to reflect an accuracy of +50% to -30% of the estimated cost in accordance with USEPA guidance (USEPA, 1988).

There is no capital cost associated with Alternatives FB-2 and AL-2. Annual costs are estimated at \$155,719 (2nd year) and \$75,074 (4th year) for FB-2. Annual costs are estimated at \$97,324 (2nd year) and \$46,922 (4th year) for AL-2. The cumulative net present value of these costs over 5, 10, 15, 20, 25 and 30-year periods, including periodic costs (e.g., five-year reviews), assuming an inflation rate of 3.0% and an initial discount rate of 5.0% for the first 15 years, then 4.0% thereafter, are summarized below.

FB-2

Operational Period	Cumulative Net Present Value (-30%)	Cumulative Net Present Value	Cumulative Net Present Value (+50%)
5-Years	$443,873	$634,105	$951,157
10-Years	$683,556	$976,509	$1,464,763
15-Years	$901,265	$1,287,522	$1,931,283
20-Years	$1,136,397	$1,623,425	$2,435,137
25-Years	$1,360,440	$1,943,486	$2,915,229
30-Years	$1,573,917	$2,248,453	$3,372,679

AL-2

Operational Period	Cumulative Net Present Value (-30%)	Cumulative Net Present Value	Cumulative Net Present Value (+50%)
5-Years	$289,709	$413,870	$620,806
10-Years	$444,880	$635,542	$953,314
15-Years	$585,824	$836,892	$1,255,338
20-Years	$738,145	$1,054,493	$1,581,740
25-Years	$883,283	$1,261,832	$1,892,749
30-Years	$1,021,575	$1,459,393	$2,189,090

These costs reflect the costs associated with the current monitoring program at the Site, which includes the sampling of 14 and 10 wells installed within the bedrock and alluvium, respectively, and 2 other wells. A detailed breakdown of these costs is provided in **Appendix D.**

5.2.3 ALTERNATIVE AL-3: GROUNDWATER COLLECTION, EX-SITU TREATMENT AND DISCHARGE

Alternative AL-3 involves all of the measures proposed under Alternative AL-2, plus the collection of COC impacted groundwater from the alluvium, treating the groundwater using carbon adsorption, and discharging it to the POTW (after analysis to ensure effluent quality) to achieve the Site RAOs. The groundwater treatment system would extract groundwater from four extraction wells located within the wetlands area. The individual extraction well pumping rate is estimated at 10 gpm (based on monitoring and slug test data) with a total combined extraction well pumping rate estimated at 40 gpm. The exact well locations and grouping, and the pumping rates to be used will be determined during the pre-design investigations. COC concentrations within the groundwater treatment system, including treatment system effluent, would be monitored monthly.

Site-specific information and analysis of this alternative relative to the nine NCP criteria are provided in the following sections.

5.2.3.1 Overall Protection of Human Health and the Environment

Implementing Alternative AL-3 would protect human health over the long term. Site RAOs would be achieved through a combination of physical removal of COC impacted groundwater from the aquifer, ICs, wellhead treatment and groundwater monitoring. There is some uncertainty as to the timeframe required by a groundwater extraction and treatment system to meet RAOs, and the time period may exceed 30 years. This alternative is protective of human health and the environment.

5.2.3.2 Compliance with ARARs

Alternative AL-3 through groundwater pump and treat, ICs, wellhead treatment, and long-term monitoring is expected to be compliant with ARARs that regulate drinking water (e.g., SDWA and Missouri WQS) although the time frame for compliance is uncertain. In addition, potential discharge of treated groundwater to the POTW or surface water body (i.e., Wetland Creek) is expected to be compliant with MDNR WQS and fulfill the NPDES substantive requirements.

Remedial activities within the wetlands area include: construction of wells; trenching for conveyance piping; and provision of power and construction of the treatment system as well as, temporary works required to facilitate access of heavy construction equipment (delivery trucks etc.). These activities will be designed to comply with location-specific and action-specific ARARs as detailed in **Appendix B**. Waste generated as a consequence of treatment operations (spent granulated active carbon) will meet Standards for Owners and Operators of Hazardous Waste and Treatment, Storage and Disposal facilities, as well as Standards Applicable to Transporters of Hazardous Waste. Alternative AL-3 is expected to meet all Federal, State, and local ARARs.

5.2.3.3 Long-Term Effectiveness and Permanence

The objective of the pump and treat system proposed under Alternative AL-3 is to create a capture zone that encompasses the COC impacted alluvium groundwater, thus providing containment for the impacted groundwater plume and permanently removing COCs from groundwater within the alluvium. The effectiveness of the pump and treat system would need to be evaluated as part of groundwater monitoring and five-year reviews. The pump and treat system will increase the hydraulic gradient between the bedrock and alluvium. As a result, this may induce acceleration of COC mass flux from the bedrock to alluvium. Furthermore, this increased gradient could result in an expanded zone of COC impact in the fractured bedrock. As part of this ongoing monitoring/review, the need for wellhead treatment systems, adjustments/cessation of groundwater extraction/treatment, and groundwater quality monitoring would be evaluated. Alternative AL-3 is considered moderately effective over the long term for the Site.

5.2.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative AL-3 uses physical processes to remove COCs from groundwater within the alluvium and reduce concentrations to TCLs. This alternative has the potential to reduce the volume of COCs and their toxicity. The pump and treat component of this alternative will create hydraulic gradients within the alluvium that may influence groundwater within the bedrock fractures. Movement of groundwater in the bedrock fractures, induced by groundwater extraction activity, may remobilize COCs and/or increase COC transport rates. Given, the complex nature of the bedrock fracturing, it is possible that control over remobilized COCs could be lost as a consequence of a change in Site conditions, such as a rainfall event, or changing the operation of the alluvium groundwater collection system. In such a case, COC mobility could be increased and uncontrolled. Alternative AL-3, therefore, is considered moderately effective at satisfying this criterion.

5.2.3.5 Short-Term Effectiveness

Alternative AL-3 requires the construction and installation of extraction wells and remedial equipment within the wetland area. Potential for worker exposure to chemicals occurs during:

- Drilling operations;
- Work with the aboveground water; and
- Sampling activities.

The drilling of extraction wells may produce contaminated soil cuttings and liquids that present some risk to workers at the Site.

Alternative AL-3 also requires substantial routine O&M, including periodic part replacement, and carbon change-out. Long-term groundwater monitoring has minimal impact on workers responsible for periodic groundwater sampling.

The time to achieve TCLs via this alternative is constrained by sorption of the COCs onto soil particles within the aquifer and the rate of discharge of COCs from the bedrock. It is anticipated that COC concentrations will exceed TCLs for a time scale of greater than 30 years. Alternative AL-3 is expected to present short-term effects.

5.2.3.6 Implementability

Alternative AL-3 is theoretically, technically, and administratively implementable at the Site, although the fulfillment of the location specific ARARs may make application of this alternative problematic. The location of the treatment components in the wetlands may create a minor visual and auditory nuisance and full compliance with location-specific ARARs will be required. Ecological studies to support the construction of the treatment system and contingency measures for system failure are likely to be required. Power requirements for the treatment system may further complicate the implementation of this alternative. Permits and permissions will be required to construct and operate the system.

Discharge of treated water to the POTW or surface water requires compliance with effluent discharge limits and NPDES permits. In addition, waste documentation and manifest preparation are required to recycle or dispose spent GAC. The aboveground treatment components are readily available, standard, industry accepted technologies.

ICs that are developed as part of this alternative may require administrative activity and legal action. ICs may be implemented without significant delays. Long-term monitoring would not interfere with onsite activities nor would it interfere with the implementation of future response actions within the Site. The equipment and services to collect groundwater samples are commercially available.

Considering the difficulties associated with working off Site, in particular, the likely restrictions imposed on working in the wetland area, Alternative AL-3 is considered difficult to implement.

5.2.3.7 Cost

A range of costs have been prepared to reflect an accuracy of +50% to -30% of the estimated cost in accordance with USEPA guidance (USEPA, 1988).

The capital cost of Alternative AL-3 is estimated to be $485,692. Annual costs are estimated at $412,165 (2nd year) and $272,259 (4th year). The cumulative net present value of these costs over 5, 10, 15, 20, 25 and 30-year periods, including periodic costs (e.g., five-year reviews), assuming an inflation rate of 3.0% and an initial discount rate of 5.0% for the first 15 years, then 4.0% thereafter, are summarized below:

Operational Period	Cumulative Net Present Value (-30%)	Cumulative Net Present Value	Cumulative Net Present Value (+50%)
5-Years	$1,548,877	$2,212,681	$3,319,021
10-Years	$2,374,037	$3,391,481	$5,087,221
15-Years	$3,121,174	$4,458,820	$6,688,230
20-Years	$3,925,886	$5,608,409	$8,412,614
25-Years	$5,058,866	$7,226,951	$10,840,427
30-Years	$5,801,671	$8,288,101	$12,432,151

A detailed breakdown of these costs is provided in **Appendix D.**

5.2.4 ALTERNATIVE AL-4: EBD

Alternative AL-4 involves all of the measures proposed under Alternative AL-2, plus the injection of an agent to enhance bio-degradation (such as HRC) into the alluvium aquifer to achieve the Site RAOs. HRC injection into the aquifer, or some other form of EBD would stimulate biological activity and accelerate the dehalogenation process of chlorinated VOCs in alluvial groundwater. A barrier design treatment approach is proposed for estimation purposes, which is intended to reduce the risk associated with the downgradient migration of COCs. For estimation purposes, HRC would be injected into the alluvium using five 2-inch injection wells located at approximate 10-foot centers. The exact injection well locations, configuration and injection frequency will be determined during pre-design investigations.

Site-specific information and analysis of this alternative relative to the nine NCP criteria are provided in the following sections.

5.2.4.1 Overall Protection of Human Health and the Environment

Implementing Alternative AL-4 would protect human health over the long term. Site RAOs would be achieved through EBD, ICs, wellhead treatment and groundwater monitoring. There is some uncertainty as to the timeframe required by EBD injection to meet RAOs, and the time period may exceed 30 years. This alternative is protective of human health and the environment.

5.2.4.2 Compliance with ARARs

Alternative AL-4 through EBD, ICs, wellhead treatment, and long-term monitoring is expected to be compliant with ARARs that regulate drinking water (e.g., SDWA and Missouri WQS) although the time frame for compliance is uncertain.

Remedial activities within the wetlands area include implementation of EBD (which for the purpose of estimating includes construction of injection wells and HRC injection). These activities will be designed to comply with location-specific and action-specific ARARs as detailed in **Appendix B**. Alternative AL-4 is expected to meet all Federal, State, and local ARARs.

5.2.4.3 Long-Term Effectiveness and Permanence

The objective of the EBD proposed under Alternative AL-4 is to reduce the risk associated with the downgradient migration of COCs at targeted areas within the alluvium. The effectiveness of EBD would need to be evaluated as part of groundwater monitoring and five-year reviews. As part of this ongoing monitoring/review, adjustments/cessation of EBD, the need for wellhead treatment systems, and groundwater quality monitoring would be evaluated. Alternative AL-4 is considered moderately effective over the long term for the Site.

5.2.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative AL-4 uses reductive dehalogenation processes to reduce the mass and volume of COCs from groundwater within the alluvium and reduce concentrations to TCLs. The effectiveness of EBD to accelerate the dehalogenation process depends on the suitability of the Site's geochemical and biological conditions for biodegradation of COCs. Alternative AL-4 is considered moderately effective at satisfying this criterion.

5.2.4.5 Short-Term Effectiveness

Alternative AL-4 requires the construction and installation of injection wells within the wetland area. Potential for worker exposure to chemicals occurs during:

- Drilling operations;
- Work with the aboveground water; and
- EBD agent injection.

The drilling of injection wells may produce contaminated soil cuttings and liquids that present some risk to workers at the Site. Long-term groundwater monitoring has minimal impact on workers responsible for periodic groundwater sampling.

The time to achieve TCLs via this alternative depends on the suitability of the Site's geochemical and biological conditions for biodegradation of COCs and the rate of discharge of COCs from the bedrock. It is anticipated that COC concentrations will exceed TCLs for a time scale of greater than 30 years.

5.2.4.6 Implementability

Alternative AL-4 is theoretically, technically, and administratively implementable at the Site. The installation of injection wells and the injection of an EBD agent into the aquifer can be readily implemented using conventional equipment and resources. ICs that are developed as part of this alternative may require administrative activity and legal action. ICs may be implemented without significant delays. Long-term monitoring would not interfere with onsite activities nor would it interfere with the implementation of future response actions within the Site. The equipment and services to collect groundwater and water samples are commercially available. Alternative AL-4 is readily implemented.

5.2.4.7 Cost

A range of costs have been prepared to reflect an accuracy of +50% to -30% of the estimated cost in accordance with USEPA guidance (USEPA, 1988).

Annual costs are estimated at \$327,174 (2nd year) and \$121,995 (4th year). The cumulative net present value of these costs over 5, 10, 15, 20, 25 and 30-year periods, including periodic costs (e.g., five-year reviews), assuming an inflation rate of 3.0% and an initial discount rate of 5.0% for the first 15 years, then 4.0% thereafter, are summarized below:

Operational Period	Cumulative Net Present Value (-30%)	Cumulative Net Present Value	Cumulative Net Present Value (+50%)
5-Years	$1,075,833	$1,536,904	$2,305,356
10-Years	$1,545,373	$2,207,676	$3,311,515
15-Years	$2,012,325	$2,874,750	$4,312,125
20-Years	$2,472,699	$3,532,427	$5,298,640
25-Years	$2,952,924	$4,218,463	$6,327,694
30-Years	$3,370,898	$4,815,568	$7,223,352

A detailed breakdown of these costs is provided in **Appendix D.**

5.2.5 ALTERNATIVE AL-5: MONITORED NATURAL ATTENUATION

Alternative AL-5 involves all of the measures proposed under Alternative AL-2, plus MNA to achieve the Site RAOs. Natural attenuation refers to a variety of physical, chemical, as well as biological mechanisms (reductive dehalogenation processes), which act to reduce the mobility, toxicity, and/or mass of COCs in groundwater. MNA refers to ongoing monitoring of groundwater to evaluate conditions and verify/confirm that natural processes are on track to achieve TCLs. To establish the viability of using MNA as an appropriate alternative for alluvial groundwater will require collation and assessment of data to meet the OSWER selection criteria (USEPA, 1997), and performance monitoring to evaluate remedy effectiveness and to ensure protection of human health and the environment.

Site-specific information and analysis of this alternative relative to the nine NCP criteria are provided in the following sections.

5.2.5.1 Overall Protection of Human Health and the Environment

Implementing Alternative AL-5 would protect human health over the long term. Site RAOs would be achieved through a combination of MNA, ICs, and wellhead treatment. There is some uncertainty as to the timeframe required by MNA to meet RAOs, and the period may exceed 30 years. This alternative is expected to be protective of human health and the environment.

5.2.5.2 Compliance with ARARs

Alternative AL-5 through MNA, ICs, and wellhead treatment is expected to be compliant with ARARs that regulate drinking water (e.g., SDWA and Missouri WQS) although the time frame for compliance is uncertain. These activities will be designed to comply with location-specific and action-specific ARARs as detailed in **Appendix B**. Alternative AL-5 is expected to meet all Federal, State, and local ARARs.

5.2.5.3 Long-Term Effectiveness and Permanence

The effectiveness of MNA would need to be evaluated as part of groundwater monitoring and five-year reviews. As part of this ongoing monitoring/review, the need for wellhead treatment systems and groundwater quality monitoring would be evaluated. Alternative AL-5 is considered moderately effective over the long term for the Site.

5.2.5.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative AL-5 uses natural attenuation processes, mainly reductive dehalogenation, to reduce the mass of COCs from groundwater within the alluvium and reduce concentrations to TCLs. The effectiveness of MNA depends on the suitability of the Site's geochemical and biological conditions for biodegradation of COCs. Alternative AL-5 is considered moderately effective at satisfying this criterion.

5.2.5.5 Short-Term Effectiveness

Alternative AL-5 requires no aboveground treatment (beyond future wellhead treatment), thus minimizing direct worker contact with groundwater. Long-term groundwater monitoring has minimal impact on workers responsible for periodic groundwater sampling and any risks to workers can be controlled and mitigated by implementation of proper health and safety measures in accordance with OSHA 1910.120. COC concentrations in groundwater are anticipated to exceed TCLs for a time scale of greater than 30 years. Alternative AL-5 is considered to present a minimal short-term effect.

5.2.5.6 Implementability

Alternative AL-5 is technically and administratively implementable at the Site. Long-term monitoring would not interfere with onsite activities nor would it interfere with the implementation of future response actions within the Site. The equipment and services to collect groundwater water samples from monitoring wells are commercially available. ICs that are developed as part of this alternative may require administrative activity and legal action.

ICs may be implemented without significant delays. Alternative AL-5 is easy to implement at the Site.

5.2.5.7 Cost

A range of costs has been prepared to reflect an accuracy of +50% to -30% of the estimated cost in accordance with USEPA guidance (USEPA, 1988).

There is no capital cost associated with Alternative AL-5. Annual costs are estimated at $278,347 (2nd year) and $134,196 (4th year). The cumulative net present value of these costs over 5, 10, 15, 20, 25 and 30-year periods, including periodic costs (e.g., five-year reviews), assuming an inflation rate of 3.0% and an initial discount rate of 5.0% for the first 15 years, then 4.0% thereafter, are summarized below.

Operational Period	Cumulative Net Present Value (-30%)	Cumulative Net Present Value	Cumulative Net Present Value (+50%)
5-Years	$767,618	$1,096,597	$1,644,896
10-Years	$1,184,786	$1,692,551	$2,538,827
15-Years	$1,563,709	$2,233,869	$3,350,804
20-Years	$1,972,752	$2,818,217	$4,227,325
25-Years	$2,362,504	$3,375,006	$5,062,509
30-Years	$2,733,875	$3,905,536	$5,858,304

A detailed breakdown of these costs is provided in **Appendix D.**

5.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

The following analysis compares the FB and AL alternatives for each of the nine evaluation criteria.

5.3.1 COMPARATIVE ANALYSIS OF FB ALTERNATIVES

A comparison of the FB remedial alternatives was made as part of the detailed analysis. Alternatives FB-1 and FB-2 propose no or limited actions which include no active remediation and varying degrees of institutional and access controls, wellhead treatment and long-term monitoring. **Table 5-1** summarizes the comparative analysis of FB alternatives.

5.3.1.1 Overall Protection of Human Health and the Environment

Alternative FB-1 is not protective of human health and the environment because exposure to contaminated groundwater would still be an open pathway. Additionally, the use of contaminated groundwater would not be regulated or restricted. Alternative FB-2 is protective of human health and the environment from groundwater COCs through a combination of ICs and wellhead treatment, which limit exposure to residual COCs.

5.3.1.2 Compliance with ARARs

Alternatives FB-1 and FB-2 do not address groundwater contamination and hence, are not compliant with chemical-specific ARARs (e.g., MCLs, State MCLs, and MDNR WQS and GTARCs). Location-specific and most action-specific ARARs do not apply to these alternatives because either no remedial action or no intrusive remedial actions are proposed.

5.3.1.3 Long-Term Effectiveness and Permanence

No reduction in COC concentrations occurs under Alternatives FB-1 or FB-2. Under both alternatives, residual risk from COCs in groundwater would remain for an unknown period. The risk from COC impacted groundwater is managed under FB-2 through ICs and wellhead treatment, although ICs would be required for an indefinite time to ensure protectiveness. Alternative FB-1 does not satisfy this criterion, while Alternative FB-2 does.

5.3.1.4 Reduction of Toxicity, Mobility and/or Volume Through Treatment

No reduction in toxicity, mobility, or volume of COCs occurs under Alternative FB-1 or Alternative FB-2.

5.3.1.5 Short-Term Effectiveness

Alternative FB-1 creates no short-term impacts to human health because no remedial action is proposed. Alternative FB-2 is anticipated to pose minimal short-term impacts to workers, the public, and the environment during implementation. Human exposure to COCs is minimized under Alternative FB-2 as the long-term monitoring program is expected to have minimal impact on workers responsible for periodic sampling.

5.3.1.6 Implementability

Alternative FB-1 is the easiest alternative to implement. Alternative FB-2 is easy to implement because it only involves groundwater monitoring and does not have any aboveground treatment components (beyond wellhead treatment).

5.3.1.7 Cost

The costs for the FB alternatives are summarized in **Table 5.2.** Alternative FB-1 is the less costly of the two alternatives because there are no costs associated with this alternative. Comparatively, Alternative FB-2 has a projected cumulative net present value over a 30-year period of $2,248,543 (within an accuracy of +50% to –30%).

5.3.2 COMPARATIVE ANALYSIS OF AL ALTERNATIVES

A comparison of the AL alternatives was made as part of the detailed analysis. Alternatives AL-1, AL-2, and AL-5 propose no or only limited actions beyond those already being conducted at the Site and include no active remediation (beyond well head treatment), and varying degrees of monitoring and institutional controls. Alternatives AL-3 and AL-4 include all the measures proposed under alternative AL-2. However, AL-3 includes active remediation of groundwater by extraction, treatment and discharge and alternative AL-4 includes EBD. **Table 5-3** summarizes the comparative analysis of AL alternatives.

5.3.2.1 Overall Protection of Human Health and the Environment

Alternative AL-1 is not protective of human health and the environment because exposure to contaminated groundwater would still be an open pathway and the use of contaminated groundwater would not be regulated or restricted. Alternatives AL-2, AL-3, AL-4 and AL-5 are all protective of human health and the environment through a combination of ICs and wellhead treatment, which limit exposure to residual COCs. Alternative AL-3 and AL-4 further provide migration control at targeted locations within the alluvium. Migration control RAOs would be met under each of these alternatives, however, the degree to which migration control RAOs are met will be further evaluated.

5.3.2.2 Compliance with ARARs

Alternative AL-1 and AL-2 do not address groundwater contamination and therefore would not be compliant with chemical-specific ARARs that regulate drinking water quality (e.g., MCL, State MCL, and MDNR WQS and GTARCs). Location-specific and most action-specific ARARS do not apply to these alternatives because either no remedial action or no intrusive remedial actions are proposed. Alternatives AL-3, AL-4 and AL-5 are all expected to be compliant with chemical-specific ARARs although the time frame for compliance varies.

5.3.2.3 Long-Term Effectiveness and Permanence

No reduction in COC concentrations occurs under Alternatives AL-1 or AL-2. Under both alternatives, residual risk from COCs in groundwater would remain for an unknown period. The risk from COC impacted groundwater is managed under AL-2 through ICs and wellhead treatment, although ICs would be required for an indefinite time to ensure protectiveness. Alternative AL-1 does not satisfy this criterion, while Alternative AL-2 does.

Reduction in COC concentrations and risks do occur under Alternatives AL-3, AL-4 and AL-5, however to varying degrees. Under Alternative AL-3, risks are reduced by creating a capture zone that encompasses the COC impacted alluvium groundwater, thus providing containment for the impacted groundwater and permanently removing COCs from groundwater. However, AL-3 may induce acceleration of COC mass flux from the bedrock to alluvium that could result in an expanded zone of COC impact in the fractured bedrock. Alternative AL-4 reduces the risk associated with the downgradient migration of COCs at a targeted area within the alluvium. Alternative AL-5 acts to reduce the mobility, toxicity, and/or mass of COCs in groundwater through the alluvium.

5.3.2.4 Reduction of Toxicity, Mobility and/or Volume Through Treatment

No reduction in toxicity, mobility, or volume of COCs occurs under Alternatives AL-1 or AL-2. Alternative AL-3 uses physical processes to remove COCs from groundwater within the alluvium and reduce concentrations to TCLs, and has the potential to reduce the volume of COCs and their toxicity. However, movement of groundwater in the bedrock fractures, induced by groundwater extraction activity, may remobilize COCs and/or increase COC transport rates. Alternative AL-4 and AL-5 uses reductive dehalogenation processes, to reduce the mass of COCs from groundwater within the alluvium and reduce concentrations to TCLs. The effectiveness of AL-4 and AL-5 depends on the suitability of the Site's geochemical and biological conditions for biodegradation of chlorinated solvents.

5.3.2.5 Short-Term Effectiveness

Alternative AL-1 creates no short-term impacts to human health because no action is performed. Alternative AL-2 and AL-5 are anticipated to pose minimal short-term impacts to workers, the public, and the environment during implementation. Human exposure to COCs is minimized under Alternatives AL-2 and AL-5 as the long-term groundwater monitoring program is expected to have minimal impact on workers responsible for periodic sampling. Alternative AL-3 is anticipated to pose the greatest short-term impact to workers, the public, and the environment during implementation. Under Alternative AL-3, environmental drilling to install extraction wells may produce contaminated soil cuttings and liquids that present some risk to workers at the Site. In addition, Alternative AL-3 has aboveground treatment components, which will require construction and operation as well as a requirement to discharge treated water to the environment. In addition, under Alternative AL-3 there is the potential for direct contact with COCs in groundwater through the operation of the groundwater treatment system (carbon change out and sampling activity). AL-4 requires the construction and installation of EBD injection wells within the wetland area. Potential for worker exposure to chemicals occurs during: drilling operations drilling operations, working with aboveground water, and EBD agent injection.

5.3.2.6 Implementability

Alternative AL-1 is the easiest alternative to implement. Alternatives AL-2 and AL-5 are easy to implement because they only involve groundwater monitoring and do not have any aboveground treatment components (beyond wellhead treatment). Alternative AL-3 includes groundwater extraction well installation requirements as well as treatment and treated water discharge and monitoring requirements. Implementing Alternative AL-3 is also likely to require system field testing to assess optimum extraction well locations, likely required pumping rates, and likely groundwater discharge concentrations. In addition, waste documentation and manifest preparation is required to recycle or dispose of GAC under this alternative. Finally, Alternative AL-3 requires routine O&M, which includes system monitoring and sampling, replacing parts and pumps periodically, cleaning components, and replacement of carbon for the life of the treatment system. Alternative AL-3 is considered difficult to implement. Alternative AL-4 requires the installation of injection wells and the injection of an EBD agent into the aquifer, which can be readily implemented using conventional drilling equipment and resources. Alternative AL-4 is readily implemented.

5.3.2.7 Cost

The costs for the AL alternatives are summarized in **Table 5.4**. Alternative AL-1 is the least costly of the alternatives because there are no costs associated with this alternative. Comparatively, Alternative AL-2 has a projected cumulative net present value over a 30-year period of $1,459,393. Alternative AL-3 is the most costly of the alternatives with a cumulative net present value of approximately $8,288,101 over a 30-year period. Alternative AL-4 has a projected cumulative net present value over a 30-year period of $4,815,568. Alternative AL-5 has a projected cumulative net present value over a 30-year period of $3,905,536.

5.4 SUMMARY OF REMEDIAL ALTERNATIVES

Tables 5.1 and 5.3 summarize the comparative analysis of the FB and AL alternatives, respectively. In these tables, each alternative is ranked on a scale of 1 to 4 for each of the nine evaluation criteria, based on the comparative analysis presented in **Section 5.3**. An alternative that is considered to best meet an evaluation criterion has a higher score based upon the following ratings scale (1 = poor; 2 = fair; 3 = good; 4 = very good). The mandatory NCP criteria, overall protection of human health and compliance with ARARs are weighted by a factor of 10 to ensure that they have prevalence over the NCP balancing criteria. The rating of alternatives, from highest to lowest, is as follows:

5.4.1 FRACTURED BEDROCK ALTERNATIVES

The rating of alternatives, from highest to lowest, for the fractured bedrock is as follows:

- Alternative FB-1 (rating = 34 points);
- Alternative FB-2 (rating = 63 points);

Alternative FB-1, the No Action Alternative, was carried through the FS process as a baseline however this alternative fails to meet the mandatory NCP "overall protection of human health and the environment" and "compliance with ARAR" criteria and as such, cannot be considered as a viable remedial alternative for COC impacted groundwater within the fractured bedrock.

Alternative FB-2 provides overall protection of human health and the environment. However, Alternative FB-2 fails to meet the mandatory NCP "compliance with ARAR" criteria, because this alternative would not be able to reduce COC concentrations below chemical-specific ARARs/TCLs within a reasonable time frame, and as such, similar to Alternative FB-1, cannot be considered as a viable remedial alternative for COC impacted groundwater within the fractured bedrock. Alternative FB-2 would be a viable remedial alternative following a USEPA determination that it is technically impracticable to reduce COC concentrations below chemical specific ARARs/TCLs within a reasonable time frame.

5.4.2 ALLUVIUM ALTERNATIVES

The rating of alternatives, from highest to lowest, for the alluvium is as follows:

- Alternative AL-5 (rating = 95 points);

- Alternative AL-4 (rating = 92 points);
- Alternative AL-3 (rating = 89 points);
- Alternative AL-2 (rating = 63 points)
- Alternative AL-1 (rating = 34 points)

Alternative AL-1, the No Action Alternative, was carried through the FS process as a baseline however this alternative fails to meet the mandatory NCP "overall protection of human health and the environment" and "compliance with ARAR" criteria and as such, cannot be considered as a viable remedial alternative for COC impacted groundwater within the alluvium.

Alternative AL-2 provides overall protection of human health and the environment. However, Alternative AL-2 fails to meet the mandatory NCP "compliance with ARAR" criteria, because this alternative would not be able to reduce COC concentrations below chemical specific ARARs/TCLs within a reasonable time frame, and as such, similar to Alternative AL-1, cannot be considered as a viable remedial alternative for COC impacted groundwater within the alluvium.

Alternatives AL-3, AL-4 and AL-5 provide overall protection of human health and the environment and comply with ARARs, and as such, meet the basic NCP criteria for consideration. In addition, these alternatives are considered to meet the Site RAOs for alluvium.

Comparatively, Alternative AL-5 is easier to implement than Alternatives AL-3 and AL-4, is less expensive, poses less short-term human health risks and achieves the same long-term effectiveness and permanence. This also considers that AL-3 may induce mass flux and mobility of COCs. Overall, the NCP defined comparative analysis between the alluvium alternatives indicate that Alternative AL-5 (MNA) is the alternative that best meets the NCP criteria. Prior to selecting AL-5 as the selected remedy to address COC impacted groundwater within the alluvium, monitoring to assess natural attenuation would be required for a period of no less than one year to evaluate the viability of this alternative. Data collected during this year would be required to demonstrate at a minimum two of three lines of evidence, as described in **Section 4.1.2.3** to support MNA as an effective process.

6 CLOSURE / LIMITATIONS

This report has been prepared for the exclusive use of MEW Site Trust Fund Donors as it pertains to the MEW Site in Cape Girardeau, Missouri. Our services have been performed using that degree of care and skill ordinarily exercised under similar circumstances by reputable, qualified environmental consultants practicing in this or similar locations. No other warranty, either expressed or implied, is made as to the professional advice included in this report. These services were performed consistent with our agreement with our client.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We do not warranty the accuracy of information supplied by others or the use of segregated portions of this report.

The purpose of a geologic/hydrogeologic/chemical investigation is to reasonably characterize existing subsurface conditions in the Study Area. In performing such an investigation, it is understood that no investigation is thorough enough to describe all subsurface conditions of interest at a given site. If conditions have not been identified during the investigation, such a finding should not, therefore, be construed as a guarantee of the absence of such conditions at the Study Area, but rather as the result of the services performed within the scope, limitations, and cost of the work performed.

In regard to geologic/hydrogeologic/chemical conditions, our professional opinions are based in part on interpretation of data from discrete sampling locations. It should be noted that actual conditions at unsampled locations may differ from those interpreted from sampled locations.

Respectfully submitted,
KOMEX

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Janaka Jayamaha, a Remediation Engineer with Komex, with expertise in contaminant assessment and remediation prepared the report with the title "Fractured Bedrock and Alluvium Groundwater Remediation Feasibility Study, Missouri Electric Works, Cape Girardeau, Missouri," dated July 7, 2005. Ralph M. Beck, a Missouri Registered Geologist, Senior Project Geologist with Komex, reviewed the report. His signature and stamp appear below.

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Tables

TABLES

MEW Site File
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TABLE 2.1
CONSTITUENTS OF CONCERN AND TARGET CLEANUP LEVELS
MISSOURI ELECTRIC WORKS (MEW) SITE

COCs	Observed Concentration	Potential TCLs								
		Human Health Risk	ARARs							
	Maximum (ug/L)	For 10^{-6} ICLR or HI = 1 (ug/L)	SDWA MCL (ug/L)	MDNR MCL (ug/L)	MDNR WQS (ug/L)	MDNR GTARC (ug/L)	RL (ug/L)	Proposed TCLs (ug/L)	Basis for Proposed TCLs (ug/L)
Detected PCB, VOCs and SVOCs									
1,2,4 Trichlorobenzene	62	0.17	70	70	70	70	0.40	70	MCL
1,3-Dichlorobenzene	100	28	-	-	-	-	1.20	28	Risk-Based
1,4-Dichlorobenzene	120	2.9	75	75	75	75	0.30	75	MCL
2-Chlorophenol	9J	8.9	-	-	0.1	40	10	10	RL
Aroclor 1260	110	0.002	0.5	0.5	0.000045	0.5	0.5	0.5	MCL
Benzene	83	0.97	5	5	5	5	0.40	5	MCL
Bis(2-Chloroethyl) Ether	6J	0.02	-	-	0.3	0.03	10	10	RL
Bis(2-ethylhexyl)phthalate	120	1.9	-	-	6	6	10	10	RL
Chlorobenzene	3,200	2.1	100	100	-	100	0.40	100	MCL
Chloroform	13	0.4	-	-	-	80	0.30	80	GTARC
Naphthalene	8.7J	0.3	-	-	-	100	10	100	GTARC
N-Nitrosodi-n-propylamine	8.1J	0.02	-	-	-	-	10	10	RL
Tetrachloroethene	8.6	0.02	5	5	5	5	1.40	5	MCL
Trichloroethene	13	0.17	5	5	5	5	1.90	5	MCL
Not Detected PCBs, VOCs and SVOCs									
1,2-Dichloroethane	-	0.22	5	5	5	5	5	5	MCL
1,2-Dichloropropane	-	0.015	5	5	-	5	5	5	MCL
2,4,6-Trichlorophenol	-	0.1	-	-	2	0.3	10	10	RL
2,4-Dinitrotoluene	-	0.26	-	-	0.11	0.05	10	10	RL
2,6-Dinitrotoluene	-	0.06	-	-	-	0.05	10	10	RL
3,3-Dichlorobenzidine	-	0.74	-	-	0.04	0.04	20	20	RL
4,6-Dinitro-2 Methyl Phenol	-	0.18	-	-	-	-	50	50	RL
Aroclor 1016	-	0.05	0.5	0.5	0.000045	0.5	1	1	RL>MCL
Aroclor-1221	-	0.13	0.5	0.5	0.000045	0.5	0.5	0.5	MCL
Aroclor-1232	-	0.13	0.5	0.5	0.000045	0.5	0.5	0.5	MCL
Aroclor-1242	-	0.01	0.5	0.5	0.000045	0.5	0.5	0.5	MCL

MEW Site File
3DISC104259

TABLE 2.1
CONSTITUENTS OF CONCERN AND TARGET CLEANUP LEVELS
MISSOURI ELECTRIC WORKS (MEW) SITE

COCs	Observed Concentration	Potential TCLs						Proposed TCLs (ug/L)	Basis for Proposed TCLs (ug/L)
		Human Health Risk	ARARs				RL (ug/L)		
	Maximum (ug/L)	For 10^{-6} ICLR or HI = 1 (ug/L)	SDWA MCL (ug/L)	MDNR MCL (ug/L)	MDNR WQS (ug/L)	MDNR GTARC (ug/L)			
Not Detected PCBs, VOCs and SVOCs									
Aroclor-1248	-	0.02	0.5	0.5	0.000045	0.5	0.5	0.5	MCL
Aroclor-1254	-	0.0004	0.5	0.5	0.000045	0.5	0.5	0.5	MCL
Benzo(a)anthracene	-	0.05	-	-	-	0.0044	10	10	RL
Benzo(a)pyrene	-	0.003	0.2	0.2	0.2	0.2	10	10	RL>MCL
Benzo(b) fluoranthene	-	0.08	-		0.0044	0.0044	10	10	RL>GTARC
Benzo(k)fluoranthene	-	0.15	-	-	0.0044	0.0044	10	10	RL>GTARC
Dibenzo(a,h)Anthracene	-	0.0009	-	-	0.0044	0.0044	10	10	RL>GTARC
Hexachloro-1,3-Butadiene	-	0.05	-	-	-	1	10	10	RL>GTARC
Hexachlorobenzene	-	0.01	1	1	1	1	10	10	RL>MCL
Indeno(1,2,3-cd)Pyrene	-	0.04	-	-	0.0044	0.0044	10	10	RL>GTARC
Nitrobenzene	-	0.18	-	-	17	17	10	17	GTARC
Pentachlorophenol	-	0.13	1	1	1	1	50	50	RL>MCL
Vinyl Chloride	-	0.21	2	2	2	2	5	5	RL>MCL

Abbreviations:

1. TCLs - Target Cleanup Levels
2. ARARs - Applicable or Relevant and Appropriate Requirement
3. COC - Constituent of Concern
4. ILCR - Incremental Lifetime Cancer Risk
5. HI - Hazard Index
6. ug/L - microgram per liter
7. SDWA - Safe Drinking Water Ac
8. MNDR - Missouri Department of Natural Resources
9. MCL - maximum contaminant level
10. GTARC - Groundwater Target Cleanup Level
11. RL - reporting limit

Notes:

1. Human-Health Based TCLs are based on the results of the Baseline Human Health Risk Assessment, and were established such that each COC has a hazard quotient (HQ) of 0.05 or less and a carcinogenic risk contribution of less than 10-6, and that the cumulative site risk levels fall within the USEPA acceptable risk range of less than 1 and 10-4 to 10-6 for HI and ICLR, respectively. Calculations and an explanation of the calculated "human health risk" values are enclosed as Appendix E.

2. Analytical RLs presented for VOCs and PCBs are one order of magnitude greater than the method detection limits (MDLs) detailed in USEPA's SW-846 documentation for Methods 8260B and 8082, respectively. Analytical RLs presented for SVOCs are equivalent to the estimated quantitation limits (EQLs) detailed in USEPA's SW-846 documentation for Methods 8270C.

TABLE 3.1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
No Action	Not Applicable	Not Applicable	No activities taken to address groundwater contamination. Does not achieve RAOs.	Retained for baseline comparison purposes in accordance with NCP.
Limited Action	Institutional Controls	Land and Resource Use Restrictions	Legal or administrative enforcement preventing or restricting certain uses of the land and resources.	Potentially applicable. Retained for further evaluation.
	Long-Term Monitoring	Groundwater Monitoring	Periodic groundwater monitoring to assess changes in groundwater quality that could be attributable to COC leaching, migration, natural attenuation processes, or active remediation.	Potentially applicable. Retained for further evaluation.
	Wellhead Treatment	Wellhead Treatment Systems	Install wellhead treatment systems at future water supply wells that have the potential to yield impacted groundwater.	Potentially applicable. Retained for further evaluation.
Containment	Low Permeability Cap	Clay/Soil	Compacted clay and soil cover installed over COC source areas to limit infiltration/recharge (used in association with vertical barriers discussed below). Generally does not limit leaching of COCs from smear zone into groundwater. Prone to weathering.	Potentially applicable. Retained for further evaluation.
		Asphalt	Asphalt laid over COC source areas. Relatively effective method for limiting infiltration and leaching of COCs from vadose zone into groundwater. Asphalt is susceptible to weathering and cracking. Generally does not limit leaching of COCs from the smear zone. No reduction of COCs.	Potentially applicable. Retained for further evaluation.
		Concrete	Concrete laid over COC source areas. Very effective method for limiting infiltration and leaching of COCs from vadose zone into groundwater. Concrete is susceptible to weathering and cracking. Generally does not limit leaching of COCs from the smear zone. No reduction of COCs. Relatively expensive capping option.	Potentially applicable. Retained for further evaluation.
		Geosynthetic/ Multimedia	Geomembrane and geotextile materials installed over COC source area. Effective method for limiting infiltration and leaching of COCs from vadose zone into groundwater. Least susceptible to weathering and cracking. Does not limit leaching of COCs from the smear zone. No reduction of COCs, and generally an expensive capping option.	Potentially applicable. Retained for further evaluation.
	Vertical Barriers	Slurry Wall	A subsurface vertical wall constructed by filling a vertical excavated trench with a slurry to prevent collapse of the trench walls. The wall, which is often keyed into a clay or competent bedrock, is backfilled with low-permeability material to form a subsurface vertical barrier which is used to contain or divert lateral groundwater flow.	Eliminated. Requires excavation within the bedrock to below groundwater (>40 feet bgs). Excavation will require blasting. Not technically feasible due to excavation requirement within the fractured bedrock to the depths required and the potential to remobilize COCs as a consequence of the blasting requirement.

TABLE 3.1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Containment (cont.)	Vertical Barriers (cont.)	Sheet Pile Wall	A subsurface vertical wall constructed by driving vertical sheets of steel into the ground and joining the sheets together using sealants such as grout or cement. The wall is used to contain or divert the lateral flow of groundwater.	Eliminated. The construction of a sheet pile wall into bedrock (excavation or driven) is not considered technically feasible.
		Grout Curtain Wall	A subsurface vertical wall constructed by injecting a grout mixture into soil pores under pressure to form a cemetious mass. The wall is used to contain or divert the lateral flow of groundwater.	Eliminated. Requires injection of grout under pressure into bedrock fractures with the potential to remobilze and/or create additional COC migration pathways in the bedrock. In addition, uncertainties exists concerning the viability of grouting all fractures . Not technically feasible due to difficulties associated with forming a continuous grout curtain in a fractured bedrock without remobilizing COCs.
Collection	Extraction (Groundwater Pumping)	Vertical-Drilled Extraction Wells	Widely used, effective method for COC impacted groundwater migration control and mass removal from the aquifer. Vertically drilled wells equipped with groundwater extraction pumps for collection and/or hydraulic control of COC impacted groundwater.	Potentially Applicable. Site requirements and conditions, specifically the requirement to reach specified drilling targets (fracture zones) in the fractured bedrock limit the feasibility of this process option. Angled wells are judged to have an advantage over vertical wells in terms of likelihood of intersecting fractures and achieving plume capture. Due to the complexity of the fracture system and the distribution of COC within fractures, pumping of groundwater in fractured bedrock runs considerable risk of redistributing COCs into unimpacted fractures and furthrer spreading the plume laterally, in ways that cannot be predicted or monitored. Although potentially applicable this, and any remedy which relies on pumping of groundwater in the fractured bedrock, inherently has the potential for worsening the overall situation within the study area.
		Horizontal/ Angle-Drilled Extraction Wells	Wells drilled horizontally or on an angle offset from vertical; originally developed by the oil and gas industry. Effective at locating well screens where structures and subsurface features would require the installation of a larger number of vertical-drilled wells to achieve the same objective. Groundwater extraction achieved using groundwater extraction pumps.	Potentially Applicable Specific drilling targets (fracture zones) necessitating horizontal/angle drilled wells are apparent. As such, this technology is likely to provide an advantage over conventional vertical drilled wells. Due to the complexity of the fracture system and the distribution of COC within fractures, pumping of groundwater in fractured bedrock runs considerable risk of redistributing COCs into unimpacted fractures and furthrer spreading the plume laterally, in ways that cannot be predicted or monitored. Although potentially applicable this, and any remedy which relies on pumping of groundwater in the fractured bedrock, inherently has the potential for worsening the overall situation within the study area.
		Interceptor Trench	Perforated horizontal pipe installed within a subsurface trench backfilled with permeable material to collect COC impacted groundwater. Vertical groundwater collection wells which intercept the perforated horizontal pipe, extract groundwater using pumps.	Eliminated. Requires excavation within the bedrock to below groundwater (>40 feet bgs). Excavation will require blasting. Not technically feasible due to excavation requirement within fractured bedrock to the depths required,and the potential to remobilize COCs as a consequence of the blasting requirement.

TABLE 3.1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Collection (Cont.)	Dual Phase Extraction	Dual Phase Extraction	Vertical extraction wells configured as dual phase extraction wells. Groundwater and vapors are removed using high vacuum systems or a combination of vaccum and groundwater extraction pumps. Dual phase extraction is applicable for COCs above and below the water table. The system is commonly configured as a low-vacuum technology, high vacuum technology or as a two phase system (combination of groundwater pumps and vacuum).	Potentially applicable. Retained for further evaluation.
	Enhanced Extraction	Hydraulic/ Pneumatic Fracturing	Techniques adopted from the oil and gas industry to increase the permeability of silts, clays and rock by injecting highly pressurized fluid, such as sand/water slurry or air, to extend existing fractures and to create a secondary network of fissures and channels.	Eliminated. Requires injection of fluid (water) or gas (air) under pressure into bedrock fractures with the potential to remobilze and/or create additional uncontrolled COC migration pathways in the bedrock.
		Explosive Fracturing	Detonation of explosives in boreholes to create an intensely fractured area of bedrock, thereby improving the interconnectedness of fractures and the potential yields of extraction wells.	Eliminated. Potential to create additional uncontrolled COC migration pathways and subsequent remobilization of COCs.
Ex-Situ Treatment	Physical Treatment	Separation (Suspended Solids Filtration)	Effective method for the removal of suspended solids and metals to protect downstream treatment processes. Common filters include bag filters, sand filters and bowl filters.	Eliminated. Not an applicable technology for the treatment of Site COCs. However, may be retained as a common groundwater pre-treatment technology.
		Separation (Membrane Pervaporation/ Reverse Osmosis)	Potentially effective method for removal of both organic and inorganic dissolved COCs. System uses permeable membranes to remove COCs from groundwater (membrane pervaporation). A modification of the system forces groundwater through the membran under pressure (reverse osmosis). Groundwater must be pre-treated for removal of high dissolved phase iron concentrations.	Eliminated. Higher cost compared to other ex-situ options, which can provide a similar or greater level of treatment
		Aeration	Proven and reliable pre-treatment method for the reduction of certain metal concentrations (e.g. iron) to protect downstream treatment processes from fouling or scaling. Requires follow-up clarification and/or filtration which generates sludge. May require collection and treatment of generated VOC vapors.	Eliminated. Not an applicable technology for the treatment of Site COCs. However, may be retained as a common groundwater pre-treatment technology.
		Air Stripping	Transfer of VOCs from the aqueous phase to the vapor phase by contacting air with water, typically in a countercurrent manner using packed towers or bubble tray aerators.	Potentially applicable. USEPA considers air stripping to be a presumptive technology for ex-situ treatment of dissolved VOCs in groundwater. Retained for further evaluation.
		Carbon Adsorption	Removal of dissolved COCs from groundwater by adsorption onto granular activated carbon.	Potentially applicable. USEPA considers granular activated carbon adsorption to be a presumptive technology for ex-situ treatment of dissolved organic COCs in groundwater. Retained for further evaluation.

TABLE 3.1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Ex-Situ Treatment (cont.)	Physical Treatment (cont.)	Resin Adsorption (Vapor Treatment)	Removes VOCs from a vapor stream by adsorption onto a redeemable synthetic resin media. Developed for the solvent recovery industry, the technology can be used for remediation projects when VOC concentrations are higher than for typically acceptable for activated carbon.	Eliminated. COC concentrations are expected to be too low for cost effective implementation of this technology.
	Chemical Treatment	Precipitation/ Coagulation/ Flocculation	Use of chemicals to cause groundwater COCs to precipitate out of solution. Coagulant and flocculant chemicals are used to increase the precipitate particle size/mass to ease subsequent seperation processes.	Eliminated. Not readily applicable to Site COCs.
		Chemical Oxidation	Use of chemical oxidizing agents such as ozone, hydrogen peroxide, sodium hypochlorite or potassium permanganate to convert dissolved organic compounds into innocuous end products. Can also be used to oxidize and precipitate iron and manganese for subsequent removal by filtration.	Potentially applicable. USEPA considers chemical oxidation to be a presumptive technology for ex-situ treatment of dissolved organic COCs in groundwater. Retained for further evaluation.
		Advanced Oxidation	Use of strong oxidizers, such as ozone or hydrogen peroxide, often in conjunction with ultraviolet light to promote faster and more complete destruction of dissolved organic compounds.	Potentially applicable. USEPA considers advanced oxidation to be a presumptive technology for ex-situ treatment of dissolved organic COCs in groundwater. Retained for further evaluation.
	Biological Treatment	Aerobic Reactor	Microorganisms and oxygen are used to degrade organic COCs in either a suspended growth or attached growth reactors, which include activated sludge and sequencing batch reactors. Biomass is kept suspended using mechanical or diffused aeration. In attached growth reactors, which include trickling filters and rotating biological contactors, biomass is attached to a solid substrate	Eliminated. Not readily applicable to Site COCs.
Discharge	Beneficial Re-Use	On-Site Use	Re-use of treated groundwater at the Site.	Eliminated. No on-Site re-use scenarios are apparent.
		Off-Site Use	Re-use of treated groundwater off-site	Eliminated. No off-Site re-use scenarios are apparent.
	Surface Discharge	Direct Discharge	Discharge of treated groundwater to the Wetland Creek	Potentially applicable. Retained for further evaluation.
		Indirect Discharge	Discharge of treated groundwater to a POTW, which in turn discharges to a surface water body.	Potentially applicable. Retained for further evaluation.
	Subsurface Discharge	Injection Well (Pressurized)	Discharge of treated groundwater to the subsurface using injection wells.	Eliminated. Injection wells are prone to fouling and plugging by biomass and/or mineral scale. Process option is difficult to maintain.
In-Situ Treatment	Physical Treatment	Air Sparging	In-situ air stripping of volatile COCs by injection of compressed air into groundwater. VOCs which partition into the rising air are collected by a vacuum extraction system installed in the unsaturated zone.	Eliminated. Site conditions preclude the use of this process option. Injection of air into fractured bedrock may re-mobilize COCs, and complete collection of off gas may not be possible.

TABLE 3.1
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
In-Situ Treatment (cont.)	Physical Treatment	In-Well Air Stripping	Use of double-cased well with an upper and lower screen into which compressed air is injected at depth. The injected air lifts the water in the well and causes it to flow out the upper screen. Volatile COCs are partially stripped through the air lift process. Vapors are drawn off by a vacuum extraction system and treated. The discharge of water from the upper screen and intake of water through the lower screen establishes an in-situ hydraulic circulation cell through which groundwater is repeatedly circulated and treated.	Eliminated. In-well air stripping is considered to be a pilot-scale technology. Lack of performance data in similar hydrogeologic setting. Site-specific concerns regarding the potential for fouling by iron precipitation.
	Chemical Treatment	Permeable Reactive Barriers	Installation of an engineered, subsurface treatment zone across the flow path of a dissolved COC plume. As groundwater passes through the zone, it is treated in-situ by reactive media such as zero-valent iron, or by injection of oxygen, chemicals, or nutrients. Often used in conjunction with impermeable wall sections (funnels) to force groundwater to flow through the permeable sections (gates).	Eliminated. Requires injection of chemicals under pressure into bedrock fractures with the potential to remobilze and/or create additional COC migration pathways. May require excavation within the bedrock to below groundwater (>40 feet bgs). Excavation will require blasting. Not technically feasible due to excavation requirement within fractured bedrock to the depths required.
	Thermal Treatment	Steam Injection	Pilot and field demonstration process option. Steam is forced into the saturated zone to vaporize COCs. Groundwater vapors (and COCs) are collected under vacuum.	Eliminated. Saturated zone thermal treatment is considered to be a pilot-scale technology. Lack of performance data in similar hydrogeologic setting.
		Six Phase Heating	Process option commonly applied to the vadoze zone to treat COCs. Field demonstrations have been applied to the saturated zone. Six phase heating uses electrical resistivity heating to raise the temperature of the saturated zone to a point suffficient to boil groundwater. Groundwater vapors (and COCs) are collected under vacuum.	Eliminated. Saturated zone thermal treatment is considered to be a pilot-scale technology. Lack of performance data in similar hydrogeologic setting.
	Biological Treatment	Enhanced Biodegradation	Enhanced biodegradation attempts to accelerate natural biodegradation of organic COCs to innocuous end products by providing nutrients, electron acceptors and/or microorganisms. Often involves air injection below the water table to increase oxygen concentrations.	Eliminated. Injection of nutrients, oxygen, and oxygen enriched water may re-mobilize COCs.
		Monitored Natural Attenuation	Reliance on naturally occurring subsurface processes that act to reduce the mass, toxicity, and volume of COCs in groundwater. These processes include biodegradation, dispersion, dilution, sorption, and volatilization. Typically requires long-term monitoring to verify performance.	Potentially applicable. Retained for further evaluation.

MEW Site File
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TABLE 3.2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
No Action	Not Applicable	Not Applicable	No activities taken to address groundwater contamination. Does not achieve RAOs.	Retained for baseline comparison purposes in accordance with NCP.
Limited Action	Institutional Controls	Land and Resource Use Restrictions	Legal or administrative enforcement preventing or restricting certain uses of the land and resources.	Potentially applicable. Retained for further evaluation.
	Long-Term Monitoring	Groundwater and Surface Water Monitoring	Periodic groundwater monitoring to assess changes in groundwater quality that could be attributable to COC leaching, migration, natural attenuation processes, or active remediation.	Potentially applicable. Retained for further evaluation.
	Wellhead Treatment	Wellhead Treatment Systems	Install wellhead treatment systems at future water supply wells that have the potential to yield impacted groundwater.	Potentially applicable. Retained for further evaluation.
Containment	Low Permeability Cap	Clay/Soil	Compacted clay and soil cover installed over COC source areas to limit infiltration/recharge (used in association with vertical barriers discussed below). Generally does not limit leaching of COCs from smear zone into groundwater. Prone to weathering.	Eliminated. Not an applicable technology, COC impacted soil source area not identified in the alluvium
		Asphalt	Asphalt laid over COC source areas. Relatively effective method for limiting infiltration and leaching of COCs from vadose zone into groundwater. Asphalt is susceptible to weathering and cracking. Generally does not limit leaching of COCs from the smear zone. No reduction of COCs.	Eliminated. Not an applicable technology, COC impacted soil source area not identified in the alluvium
		Concrete	Concrete laid over COC source areas. Very effective method for limiting infiltration and leaching of COCs from vadose zone into groundwater. Concrete is susceptible to weathering and cracking. Generally does not limit leaching of COCs from the smear zone. No reduction of COCs. Relatively expensive capping option.	Eliminated. Not an applicable technology, COC impacted soil source area not identified in the alluvium
		Geosynthetic/ Multimedia	Geomembrane and geotextile materials installed over COC source area. Effective method for limiting infiltration and leaching of COCs from vadose zone into groundwater. Least susceptible to weathering and cracking. Does not limit leaching of COCs from the smear zone. No reduction of COCs, and generally an expensive capping option.	Eliminated. Not an applicable technology, COC impacted soil source area not identified in the alluvium
	Vertical Barriers	Slurry Wall	A subsurface vertical wall constructed by filling a vertical excavated trench with a slurry to prevent collapse of the trench walls. The wall, which is often keyed into a clay or competent bedrock, is backfilled with low-permeability material to form a subsurface vertical barrier which is used to contain or divert lateral groundwater flow.	Potentially applicable. Retained for further evaluation.

TABLE 3.2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Containment (cont.)	Vertical Barriers (cont.)	Sheet Pile Wall	A subsurface vertical wall constructed by driving vertical sheets of steel into the ground and joining the sheets together using sealants such as grout or cement. The wall is used to contain or divert the lateral flow of groundwater.	Eliminated. The construction of a sheet pile wall to depths in excess of 70 feet bgs is not considered technically feasible.
		Grout Curtain Wall	A subsurface vertical wall constructed by injecting a grout mixture into soil pores under pressure to form a cemetious mass. The wall is used to contain or divert the lateral flow of groundwater.	Eliminated. Unlikely to provide an advantage over conventional vertical-drilled extraction wells.
Collection	Extraction (Groundwater Pumping)	Vertical-Drilled Extraction Wells	Widely used, effective method for COC impacted groundwater migration control and mass removal from the aquifer. Vertically drilled wells equipped with groundwater extraction pumps for collection and/or hydraulic control of COC impacted groundwater.	Potentially applicable. Retained for further evaluation.
		Horizontal/ Angle-Drilled Extraction Wells	Wells drilled horizontally or on an angle offset from vertical; originally developed by the oil and gas industry. Effective at locating well screens where structures and subsurface features would require the installation of a larger number of vertical-drilled wells to achieve the same objective. Groundwater extraction achieved using groundwater extraction pumps.	Eliminated. Specific drilling targets (fracture zones) necessitating horizontal/angle-drilled wells are not apparent. As such, this technology is unlikely to provide an advantage over conventional vertical-drilled wells.
		Interceptor Trench	Perforated horizontal pipe installed within a subsurface trench backfilled with permeable material to collect COC impacted groundwater. Vertical groundwater collection wells which intercept the perforated horizontal pipe, extract groundwater using pumps.	Potentially applicable. Retained for further evaluation.
	Dual Phase Extraction	Dual Phase Extraction Wells	Vertical extraction wells configured as dual phase extraction wells. Groundwater and vapors are removed using high vacuum systems or a combination of vaccum and groundwater extraction pumps. Dual phase extraction is applicable for COCs above and below the water table. The system is commonly configured as a low-vacuum technology, high vacuum technology or as a two phase system (combination of groundwater pumps and vacuum).	Eliminated. Slurry wall considered more effective and generally better representative of vertical barriers.
	Enhanced Extraction	Hydraulic/ Pneumatic Fracturing	Techniques adopted from the oil and gas industry to increase the permeability of silts, clays and rock by injecting highly pressurized fluid, such as sand/water slurry or air, to create a secondary network of fissures and channels.	Eliminated. Specific needs necessitating hydraulic/pneumatic fracturing are not apparent. As such, this technology is unlikely to provide an advantage over conventional collectionproces options.

TABLE 3.2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Collection (cont.)	Enhanced Extraction (cont.)	Explosive Fracturing	Detonation of explosives in boreholes to create an intensely fractured area, thereby improving the potential yields of extraction wells.	Eliminated. Specific needs necessitating explosive fracturing are not apparent. As such, this technology is unlikely to provide an advantage over conventional collection process options.
Ex-Situ Treatment	Physical Treatment	Separation (Suspended Solids Filtration)	Effective method for the removal of suspended solids and metals to protect downstream treatment processes. Common filters include bag filters, sand filters and bowl filters.	Eliminated. Not an applicable technology for the treatment of Site COCs. However, may be retained as a common groundwater pre-treatment technology.
		Separation (Membrane Pervaporation/ Reverse Osmosis)	Potentially effective method for removal of both organic and inorganic dissolved COCs. System uses permeable membranes to remove COCs from groundwater (membrane pervaporation). A modification of the system forces groundwater through the membran under pre	Eliminated. Higher cost compared to other ex-situ options, which can provide a similar or greater level of treatment
		Aeration	Proven and reliable pre-treatment method for the reduction of certain metal concentrations (e.g. iron) to protect downstream treatment processes from fouling or scaling. Requires follow-up clarification and/or filtration which generates sludge. May requ	Eliminated. Not an applicable technology for the treatment of Site COCs. However, may be retained as a common groundwater pre-treatment technology.
		Air Stripping	Transfer of VOCs from the aqueous phase to the vapor phase by contacting air with water, typically in a countercurrent manner using packed towers or bubble tray aerators.	Potentially applicable. USEPA considers granular activated carbon adsorption to be a presumptive technology for ex-situ treatment of dissolved organic COCs in groundwater. Retained for further evaluation.
		Carbon Adsorption	Removal of dissolved COCs from groundwater by adsorption onto granular activated carbon.	Potentially applicable. Retained for further evaluation.
	Physical Treatment (cont.)	Resin Adsorption (Vapor Treatment)	Removes VOCs from a vapor stream by adsorption onto a redeemable synthetic resin media. Developed for the solvent recovery industry, the technology can be used for remediation projects when VOC concentrations are higher than for typically acceptable for activated carbon.	Eliminated. COC concentrations are expected to be too low for cost effective implementation of this technology.
	Chemical Treatment	Precipitation/ Coagulation/ Flocculation	Use of chemicals to cause groundwater COCs to precipitate out of solution. Coagulant and flocculant chemicals are used to increase the precipitate particle size/mass to ease subsequent seperation processes.	Eliminated. Not readily applicable to Site COCs.
		Chemical Oxidation	Use of chemical oxidizing agents such as ozone, hydrogen peroxide, sodium hypochlorite or potassium permanganate to convert dissolved organic compounds into innocuous end products. Can also be used to oxidize and precipitate iron and manganese for subsequent removal by filtration.	Potentially applicable. USEPA considers chemical oxidation to be a presumptive technology for ex-situ treatment of dissolved organic COCs in groundwater. Retained for further evaluation.

TABLE 3.2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Ex-Situ Treatment (cont.)	Chemical Treatment (cont.)	Advanced Oxidation	Use of strong oxidizers, such as ozone or hydrogen peroxide, often in conjunction with ultraviolet light to promote faster and more complete destruction of dissolved organic compounds.	Potentially applicable. USEPA considers advanced oxidation to be a presumptive technology for ex-situ treatment of dissolved organic COCs in groundwater. Retained for further evaluation.
	Biological Treatment	Aerobic Reactor	Microorganisms and oxygen are used to degrade organic COCs in either a suspended growth or attached growth reactors, which include activated sludge and sequencing batch reactors. Biomass is kept suspended using mechanical or diffused aeration. In attached growth reactors, which include trickling filters and rotating biological contactors, biomass is attached to a solid substrate	Eliminated. Not readily applicable to Site COCs.
Discharge	Beneficial Re-Use	On-Site Use	Re-use of treated groundwater at the Site.	Eliminated. No on-Site re-use scenarios are apparent.
		Off-Site Use	Re-use of treated groundwater off-site	Eliminated. No off-Site re-use scenarios are apparent.
	Surface Discharge	Direct Discharge	Discharge of treated groundwater to the Wetland Creek	Potentially applicable. Retained for further evaluation.
		Indirect Discharge	Discharge of treated groundwater to a POTW, which in turn discharges to a surface water body.	Potentially applicable. Retained for further evaluation.
	Subsurface Discharge	Injection Well (Pressurized)	Discharge of treated groundwater to the subsurface using injection wells.	Eliminated. Injection wells are prone to fouling and plugging by biomass and/or mineral scale. Process option is difficult to maintain.
In-Situ Treatment	Physical Treatment	Air Sparging	In-situ air stripping of volatile COCs by injection of compressed air into groundwater. VOCs which partition into the rising air are collected by a vacuum extraction system installed in the unsaturated zone.	Eliminated. Site conditions preclude the use of this process option. Interbedded clays, silts and sands, commonly found in alluvial sediments potentially result in poor air sparge off gas collection.
	Physical Treatment	In-Well Air Stripping	Use of double-cased well with an upper and lower screen into which compressed air is injected at depth. The injected air lifts the water in the well and causes it to flow out the upper screen. Volatile COCs are partially stripped through the air lift process. Vapors are drawn off by a vacuum extraction system and treated. The discharge of water from the upper screen and intake of water through the lower screen establishes an in-situ hydraulic circulation cell through which groundwater is repeatedly circulated and treated.	Eliminated. In-well air stripping is considered to be a pilot-scale technology. Lack of performance data in similar hydrogeologic setting.
	Chemical Treatment	Permeable Reactive Barriers	Installation of an engineered, subsurface treatment zone across the flow path of a dissolved COC plume. As groundwater passes through the zone, it is treated in-situ by reactive media such as zero-valent iron, or by injection of oxygen, chemicals, or nutrients. Often used in conjunction with impermeable wall sections (funnels) to force groundwater to flow through the permeable sections (gates).	Potentially applicable. Retained for further evaluation.

TABLE 3.2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
In-Situ Treatment (cont.)	Thermal Treatment	Steam Injection	Pilot and field demonstration process option. Steam is forced into the saturated zone to vaporize COCs. Groundwater vapors (and COCs) are collected under vacuum.	Eliminated. Saturated zone thermal treatment is considered to be a pilot-scale technology. Lack of performance data in similar hydrogeologic setting.
	Thermal Treatment (cont.)	Six Phase Heating	Process option commonly applied to the vadoze zone to treat COCs. Field demonstrations have been applied to the saturated zone. Six phase heating uses electrical resistivity heating to raise the temperature of the saturated zone to a point suffficient to boil groundwater. Groundwater vapors (and COCs) are collected under vacuum.	Eliminated. Saturated zone thermal treatment is considered to be a pilot-scale technology. Lack of performance data in similar hydrogeologic setting.
	Biological Treatment	Enhanced Bio-Degradation	Enhanced bio-degradation attempts to accelerate natural biodegradation of organic COCs to innocuous end products by providing nutrients, electron acceptors and/or microorganisms. Often involves air injection below the water table to increase oxygen concentrations.	Potentially applicable. Retained for further evaluation.
		Monitored Natural Attenuation	Reliance on naturally occurring subsurface processes that act to reduce the mass, toxicity, and volume of COCs in groundwater. These processes include biodegradation, dispersion, dilution, sorption, and volatilization. Typically requires long-term monitoring to verify performance.	Potentially applicable. Retained for further evaluation.

TABLE 3.3
EVALUATION OF PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
No Action	Not Applicable	Not Applicable	Does not achieve RAOs. Groundwater will continue to exhibit COCs in excess of TCLs.	No action required, therefore no implementability restrictions.	Capital: None O&M: None	Retained for baseline comparison purposes in accordance with the NCP.
Limited Action	Institutional Controls	Land and Resource Use Restrictions.	The effectiveness of ICs depends on the mechanisms used and the durability of the IC. Land and resource use restrictions are considered effective in reducing risk to human health, although this process option does not reduce COC mobility, toxicity, or volume, and as such does not achieve all the site RAOs.	Will require administrative activity and legal action on the part of the Property owner, the State and/or local authorities. Can be implemented in combination with other process options.	Capital: Low O&M: Low	Retained as a possible remedial action alternative.
	Wellhead Treatment	Wellhead Treatment Systems	Effective method for treating groundwater to drinking water standards. Continued effectiveness will depend on the consistent use and regular maintenance of such systems. This process option, although not designed to contain or remediate a containment plume, may over time achieve TCLs. This option on its own is not designed to achieve the RAOs for Site groundwater.	Readily implemented using conventional, commercially available equipment. Common treatment systems include carbon adsorption and air stirpper units.	Capital: Moderate O&M: Moderate	Retained as a possible remedial action alternative.
	Long-Term Monitoring	Groundwater Monitoring	Effective method for observing COC migration and assessing the effectiveness of the remedial action. Does not reduce COC mobility, toxicity or volume, and as such does not achieve all the site RAOs.	Readily implemented using conventional techniques and procedures previously used at the Site, including existing and/or additional monitoring wells.	Capital: Low O&M: Moderate	Retained as a possible remedial action alternative.
Containment	Low Permeability Cap	Clay/Soil	Relatively effective method for limiting infiltration and leaching of COCs from the vadose zone into groundwater. Generally does not limit leaching of COCs from the smear zone. Does not achieve RAOs. This process option is considered to have limited effectiveness, as it requires knowledge of COC source areas and requires implementation with other containment remedial technologies, which were eliminated during the screening step.	Readily implemented by standard construction methods. Requires maintenance and restriction on future land use.	Capital: Moderate O&M: Moderate	Eliminated. To be effective capping requires remedial technologies eliminated in the earlier screening step due to technical infeasibility.

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TABLE 3.3
EVALUATION OF PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
Containment (cont.)	Low Permeability Cap (Continued)	Asphalt	Relatively effective method for limiting infiltration and leaching of COCs from the vadose zone into groundwater. Generally does not limit leaching of COCs from the smear zone. Does not achieve RAOs. This process option is considered to have limited effectiveness as it requires knowledge of COC source areas and requires implementation in conjunction with other containment remedial technologies (vertical barriers), which were eliminated during the initial screening step.	Readily implemented by standard construction methods. Requires maintenance and restriction on future land use.	Capital: Moderate to High O&M: Moderate	Eliminated. Clay/soil cap is considered a better representative of the low-permeability capping process option, because of its effectiveness at a lower cost.
		Concrete	Relatively effective method for limiting infiltration and leaching of COCs from the vadose zone into groundwater. Generally does not limit leaching of COCs from the smear zone. Does not achieve RAOs. This process option is considered to have limited effectiveness as it requires knowledge of COC source areas and requires implementation with other containment remedial technologies, which were eliminated during the screening step.	Readily implemented by standard construction methods. Requires maintenance and restriction on future land use.	Capital: High O&M: Moderate	Eliminated. Clay/soil cap is considered a better representative of the low-permeability capping process option, because of its effectiveness at a lower cost.
		Geosynthetic/ Multimedia	Relatively effective method for limiting infiltration and leaching of COCs from the vadose zone into groundwater. Generally does not limit leaching of COCs from the smear zone. Does not achieve RAOs. This process option is considered to have limited effectiveness as it requires knowledge of COC source areas and requires implementation with other containment remedial technologies, which were eliminated during the screening step.	Readily implemented by standard construction methods. Requires maintenance and restriction on future land use.	Capital: High O&M: Moderate	Eliminated. Clay/soil cap is considered a better representative of the low-permeability capping process option, because of its effectiveness at a lower cost.

TABLE 3.3
EVALUATION OF PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
Collection	Extraction (Groundwater Pumping)	Vertical-Drilled Extraction Wells	Widely used, effective method for COC impacted groundwater migration control and mass removal from the aquifer. Vertically drilled wells equipped with groundwater extraction pumps for collection and/or hydraulic control of COC impacted groundwater. Effectiveness is limited by an ability to identify the major vertical fractures and the predictability of the exact location of the fractures. Does not achieve the Site RAOs	Difficult to implement. The identification, exact locations and practical intersection of all the COC impacted fracture zones is considered practically infeasible.	Capital: High O&M: Moderate	Eliminated. Site requirements and conditions, specifically the requirement to reach specified drilling targets (fracture zones) in the fractured bedrock limit the feasibility of this process option. Angled wells are judged to have an advantage over vertical wells in terms of likelihood of intersecting fractures and achieving plume capture.
		Horizontal/Angle-Drilled Extraction Wells	Angle-drilled wells are considered more likely to achieve vertical fracture intercept than the more common, widely used vertical drilled extraction wells. Does not achieve the Site RAOs.	Specialized drilling techniques are used to drill wells at an angle, to reach COCs not accessible by direct vertical drilling. Difficult to implement. The identification, exact locations and practical intersection of all the COC impacted fracture zones is considered practically infeasible.	Capital: High O&M: Moderate	Eliminated. Angle-drilled extraction wells although offering an advantage over vertical-drilled wells still have limited effectiveness and are considered just as difficult to implement. Angle-drilled wells are likely to be very costly, requiring specialized equipment.
	Dual Phase Extraction	Dual Phase Extraction Wells	Widely used, effective method for COC impacted groundwater migration control and contaminant mass removal from the aquifer. System typically comprises vertically drilled wells configured as dual extraction wells. Groundwater and vapors are removed using high vacuum systems or a combination of vaccum and groundwater extraction pumps. Effectiveness may be limited by the low yield of the fractured bedrock and the ability to identify the major vertical fractures and the predictability of the exact location of these fractures. Does not achieve the Site RAOs.	Difficult to implement. The identification, exact locations and practical intersection of all the COC impacted fracture zones is considered practically infeasible.	Capital: High O&M: Moderate	Eliminated. More expensive than traditional groundwater pumping and is not considered to offer a higher level of treatment.
Ex-Situ Treatment	Physical Treatment	Aeration	Proven and reliable pre-treatment method for the reduction of certain metal (e.g., iron) concentrations to protect downstream treatment processes from fouling or scaling. Requires follow-up clarification and/or filtration which generates sludge. May require collection and treatment of VOC vapors.	Readily implemeted using commercialy available equipment.	Capital: Low O&M: Low	Eliminated. Ex-situ treatment process options are dependent on groundwater collection process options, therefore, with the elimination of groundwater treatment process options, ex-tratment process options are no longer applicable or relevant.

TABLE 3.3
EVALUATION OF PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
Ex-Situ Treatment (Continued)	Physical Treatment (Continued)	Air Stripping	Well-developed, widely used technology, which is effective for removal of most halogenated and non-halogenated VOCs dissolved in groundwater. Pre-treatment for metals (e.g., iron) removal and to control hardness may be necessary. Post-treatment by carbon adsorption to meet discharge limits may also be necessary. Does not destroy COCs. Off-gas treatment may require treatment. Does not achieve the site RAOs.	Readily implemeted using conventional, commerciaiy available equipment.	Capital: Moderate to High O&M: Moderate to High	Eliminated. Ex-situ treatment process options are dependent on groundwater collection process options, therefore, with the elimination of groundwater treatment process options, ex-situ treatment process options are no longer applicable or relevant.
		Carbon Adsorption	Well developed, widely used technology which is effective for removal of most halogenated and non-halogenated VOCs and SVOCs dissolved in the groundwater. Pre-treatment for metals (e.g., iron and manganese) removal and to control hardness may be necessary. COCs are not destroyed, but transferred to activated carbon surface. Spent carbon may require disposal/ reactivation as a hazardous waste. Does not achieve the site RAOs.	Readily implemeted using conventional, commerciaiy available equipment.	Capital: Moderate O&M: Low to Moderate	Eliminated. Ex-situ treatment process options are dependent on groundwater collection process options, therefore, with the elimination of groundwater treatment process options, ex-situ treatment process options are no longer applicable or relevant.
		Vapor Phase Carbon Adsorption	Vapor-phase carbon adsorption is a well developed, widely used process, which is effective for the removal of most VOC-laden vapor streams generated from air stripping operations. Pre-treatment of VOC-laden vapors to reduce the temperature and relative humidity is generally necessary to prevent loss of carbon adsorption capacity and improve COC removal efficiencies.	Readily implemented using commercially available equipment. Planning for the regeneration, reactivation, or disposal of spent carbon must be considered as part of implementation. On-Site steam regeneration of spent carbon would likely generate a liquid hazardous waste. Off-Site reactivation and/or disposal may require handling the spent carbon as a hazardous waste. It is not recommended to remove high COC concentrations.	Capital: Moderate O&M: Low to Moderate	Eliminated. Ex-situ treatment process options are dependent on groundwater collection process options, therefore, with the elimination of groundwater treatment process options, ex-situ treatment process options are no longer applicable or relevant.
	Chemical Treatment	Chemical Oxidation	Chemical oxidation is a potentially effective method for both the destruction of dissolved organic COCs and the precipitation of iron, which is present in Site groundwater. This process is not in common use for groundwater treatment applications.	Readily implemented using commercially available equipment. This process is likely to generate sludge from the precipitation of iron. Sludge may be hazardous and require appropriate treatment/disposal at an off-Site RCRA-permitted facility.	Capital: Low O&M: Moderate to High	Eliminated. Ex-situ treatment process options are dependent on groundwater collection process options, therefore, with the elimination of groundwater treatment process options, ex-situ treatment process options are no longer applicable or relevant.

TABLE 3.3
EVALUATION OF PROCESS OPTIONS FOR FRACTURED BEDROCK
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
Ex-Situ Treatment (Continued)	Chemical Treatment (Continued)	Advanced Oxidation	Advanced oxidation is a well-developed, increasingly used process, which has proven effective for destruction of the COCs present in Site groundwater. As a destruction process, it is advantageous in that it does not transfer COCs to another medium. Does not achieve the site RAOs.	Advanced oxidation is readily implemented for treatment of Site groundwater using commercially available equipment from a limited number of vendors. Studies are required to match the oxidant and COCs. Waste streams are produced following treatment that require either additional treatment or disposal.	Capital: High O&M: High	Eliminated. Ex-situ treatment process options are dependent on groundwater collection process options, therefore, with the elimination of groundwater treatment process options, ex-situ treatment process options are no longer applicable or relevant.
Discharge	Surface Discharge	Direct Discharge	Discharge to Wetland Creek is an effective means of final disposition of the volume of water expected to be generated by groundwater collection and treatment.	The implementability of this method would depend on discharge water quality standards (WQS) for the Wetland Creek, and whether the treatment system can achieve the standards	Capital: Moderate O&M: Moderate	Eliminated. Discharge process options are dependent on groundwater collection and ex-situ treatment process options, therefore, with the elimination of both of these process options, discharge process options are no longer applicable or relevant.
		Indirect Discharge	Discharge to POTW is an effective means of final disposition of the volume of water expected to be generated by groundwater collection and treatment.	The implementability of this method would depend on the sewer discharge permit requirements. Discharge to the POTW might require crossing public and/or private property, and obtaining rights-of-way for a discharge pipeline.	Capital: Moderate O&M: Moderate	Eliminated. Discharge process options are dependent on groundwater collection and ex-situ treatment process options, therefore, with the elimination of both of these process options, discharge process options are no longer applicable or relevant.
In-Situ Treatment	Biological Treatment	Monitored Natural Attenuation	Consideration of this option usually requires modeling and evaluation of COC degradation rates and pathways and predicting COC concentration at down gradient receptor points, especially when plume is still expanding/migrating. Effectiveness of this option is limited due to impracticability of existing techniques to identify all the fractures that carry contaminated groundwater through the bedrock. Does not achieve site RAOs.	Readily implementable. The evaluation of natural attenuation is often not straightforward and will require expertise in several technical areas including microbiology/bioremediation, hydrogeology, and geochemistry.	Capital: Moderate O&M: Moderate	Eliminated. Technically infeasible to monitor natural attenuation processes with a high degree of certainty.

TABLE 3.4
EVALUATION OF PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
No Action	None	Not Applicable	Does not achieve RAOs. Groundwater will continue to exhibit COCs in excess of TCLs.	No action required, therefore no implementability restrictions.	Capital: None O&M: None	Retained for baseline comparison purposes in accordance with the NCP.
Limited Action	Institutional Controls	Land and Resource Use Restrictions.	The effectiveness of ICs depends on the mechanisms used and the durability of the IC. Land and resource use restrictions are considered effective in reducing risk to human health, although this process option does not reduce COC mobility, toxicity, or volume, and as such does not achieve all the site RAOs.	Will require administrative activity and legal action on the part of the Property owner, the State and/or local authorities. Can be implemented in combination with other process options.	Capital: Low O&M: Low	Retained as a possible remedial action alternative.
	Long-Term Monitoring	Groundwater and Surface Water Monitoring	Effective method for observing COC migration and assessing the effectiveness of the remedial action. Does not reduce COC mobility, toxicity or volume, and as such does not achieve all the site RAOs.	Readily implemented using conventional techniques and procedures previously used at the Site, including existing and/or additional monitoring wells.	Capital: Low O&M: Moderate	Retained as a possible remedial action alternative.
	Wellhead Treatment	Well Treatment Systems	Effective method for treating groundwater to drinking water standards. Continued effectiveness will depend on the consistent use and regular maintenance of such systems. This process option, although not designed to contain or remediate a containment plume, may over time achieve TCLs. This option on its own is not designed to achieve the RAOs for Site groundwater.	Readily implemented using conventional, commercially available equipment. Common treatment systems include carbon adsorption and air stripper units.	Capital: Moderate O&M: Moderate	Retained as a possible remedial action alternative.
Containment	Vertical Barriers	Slurry Wall	Demonstrated effectiveness in containing groundwater; however, in COC impacted groundwater applications, specific COC types may degrade the slurry wall components and reduce the long-term effectiveness. The installation of the slurry wall poses risks to human health such as, exposure to COC impacted soil and groundwater and risks associated with working with heavy construction equipment. This process option does not restrict the use of the aquifer for drinking water and does not achieve the Site RAOs	Construction of a slurry wall into the underlying clay (i.e., approximately 100 feet bgs) is not considered feasible due to the deep excavation and specialized heavy construction equipment required. Large volumes of material will need to be transported from and to the Site to complete the installation and the construction of temporary haul roads across the wetland area. In addition to difficulties associated with the slurry wall installation, the implementation and future enforcement of ICs, which would be required in conjunction with this option to prevent human excavation of the barrier, is potentially problematic.	Capital: High O&M: Moderate	Eliminated. Possible reduced long term effectiveness, increased short term health risks, difficulties foreseen for implementation, and high cost.

TABLE 3.4
EVALUATION OF PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
Collection	Extraction (Groundwater Pumping)	Vertical-Drilled Extraction Wells	Widely used, effective method for COC impacted groundwater migration control and mass removal from the aquifer. Vertically drilled wells equipped with groundwater extraction pumps for collection and/or hydraulic control of COC impacted groundwater. The effectiveness of vertical-drilled extraction wells to extract groundwater is controlled primarily by the permeability of the aquifer. Vertical-drilled wells do not reduce human health risks, as they do not restrict use of the groundwater, therefore, vertical-drilled wells on their own do not achieve all the Site RAOs. In addition, the installation of vertical-drilled extraction wells potentially exposes workers to COC impacted soils and groundwater.	Readiliy implemented using standard well construction techniques. A vertical-drilled extraction well system is considered moderate to difficult to implement for the alluvium at the Site. Implementation would require movement of heavy equipment over the wetland (unstable ground conditions). In addition, the implementation of a drilling program in the wetlands area will have to comply with location specific ARARs such as the Protection of Wetland (Executive Order 11990)	Capital: Moderate O&M: Moderate	Retained as a potential component of a remedial action alternative focused on COC impacted alluvium groundwater.
		Interceptor Trench	The effectiveness of the interceptor trench is governed by the permeability of the backfill material and in particular, the permeability of the perforated horizontal collection pipe. Biological activity and sedimentation around the pipe can lead to clogging of pipe perforations and reduction in groundwater collection efficiency. An interceptor trench does not reduce human health risks, as it does not restrict use of the groundwater, therefore, an interceptor trench does not on it's own achieve all the Site RAOs. The installation of an interceptor trench poses additional risks to human health such as, exposure to COC impacted soil and groundwater and risks associated with working with heavy construction equipment.	An interceptor trench excavated to 100 feet bgs cannot be implemented using readily available equipment and will require specialized equipment and excavation techniques. Installation of a deep interceptor trench will also require either stable ground conditions or trench support. In addition, the implementation excavation activity in the wetlands area will have to comply with location specific ARARs such as, the Protection of Wetland (Executive Order 11990).	Capital: High O&M: Moderate to High	Eliminated. Potentially ineffective over a long period, difficult to implement, requiring specialized equipment and excavation techniques and likely to be costly compared to other collection technologies.
Ex-Situ Treatment	Physical Treatment	Air Stripping	Well-developed, widely used technology, which is effective for removal of most halogenated and non-halogenated VOCs dissolved in groundwater. Pre-treatment for metals (e.g., iron) removal, and to control hardness may be necessary. Post-treatment by carbon adsorption to meet discharge limits may also be necessary. Does not destroy COCs. Off-gas may require treatment. Does not achieve the Site RAOs.	Air stripping is readily implementable for the treatment of Site groundwater using commercially available equipment and conventional installation methods. The construction of a treatment system in the wetlands area will have to comply with location specific ARARs such as the Protection of Wetland (Executive Order 11990)	Capital: Moderate to High O&M: Moderate to High	Eliminated. Other potentially less expensive options are available that provide a similar or higher level of treatment.

MEW Site File
3DISC104276

TABLE 3.4
EVALUATION OF PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
Ex-Situ Treatment (cont.)	Physical Treatment	Carbon Adsorption	Well developed, widely used technology which is effective for removal of most halogenated and non-halogenated VOCs and SVOCs dissolved in Site groundwater. Pre-treatment for metals (e.g., iron) removal and to control hardness may be necessary. COCs are not destroyed, but transferred to carbon. Spent carbon may require disposal/ reactivation as a hazardous waste. Does not achieve the Site RAOs.	Carbon adsorption could be readily implemented for the treatment of Site groundwater using commercially available equipment and conventional installation methods. Pilot testing is warranted to evaluate removal efficiencies and other design information. Planning for the reactivation or disposal of spent carbon must be considered as part of implementation. Offsite reactivation and/or disposal may require handling the spent carbon as a hazardous waste. The construction of a treatment system in the wetlands area will have to comply with location specific ARARs such as the Protection of Wetland (Executive Order 11990)	Capital: Moderate O&M: Low to Moderate	Retained as a potential component of a remedial action alternative focused on groundwater treatment.
	Chemical Treatment	Chemical Oxidation	Chemical oxidation is a potentially effective method for both the destruction of dissolved organic COCs and the precipitation of iron, which is present in Site groundwater. This process is not in common use for groundwater treatment applications.	Readily implemented using commercially available equipment. This process would likely generate sludge from the precipitation of iron. Sludge may be hazardous and require appropriate treatment/disposal at an off-Site RCRA-permitted facility.	Capital: Low O&M: Moderate to High	Eliminated. Limited record of accomplishment in groundwater treatment applications as compared to other ex-situ treatment process options.
		Advanced Oxidation	Advanced oxidation is a well-developed, increasingly used process, which has proven effective for destruction of the COCs present in Site groundwater. As a destruction process, it is advantageous in that it does not transfer COCs to another medium. Does not achieve the site RAOs.	Advanced oxidation is readily implemented for treatment of Site groundwater using commercially available equipment from a limited number of vendors. Studies are required to match the oxidant and COCs. Waste streams are produced following treatment that require either additional treatment or disposal.	Capital: High O&M: High	Eliminated. Potentially less expensive options are available that provide a similar or higher level of treatment.
Discharge	Surface Discharge	Direct Discharge	Discharge to Wetland Creek is an effective means of final disposition of the volume of water expected to be generated by groundwater collection and treatment.	The implementability of this method would depend on discharge water quality standards (WQS) for the Wetland Creek, and whether the treatment system can achieve the standards	Capital: Moderate O&M: Moderate	Retained as a potential component of a Site groundwater remedial action alternative.
		Indirect Discharge	Discharge to POTW is an effective means of final disposition of the volume of water expected to be generated by groundwater collection and treatment.	The implementability of this method would depend on the sewer discharge permit requirements. Discharge to the POTW might require crossing public and/or private property, and obtaining rights-of-way for a discharge pipeline.	Capital: Moderate O&M: Moderate	Retained as a potential component of a Site groundwater remedial action alternative.

MEW Site File
3DISC104277

TABLE 3.4
EVALUATION OF PROCESS OPTIONS FOR ALLUVIUM
MISSOURI ELECTRIC WORKS (MEW) SITE

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Cost	Retain/Eliminate
In-Situ Treatment	Biological Treatment	Enhanced Bio-Degradation (EBD)	Applying EBD to the subsurface for effective remediation can be difficult and uncertain. The effectiveness of EBD to stimulate biological activity and accelerate the degradation process depends on the suitability of the Site's geochemical/biological condition for biodegradation of chlorinated VOCs. Additionally, since the source location of discharge of COCs to the alluvium groundwater at depth from the bedrock is unknown, this process option will require further investigation to identify appropriate application locations.	EBD can be readily implemented for COC impacted alluvium groundwater using conventional equipment and resources. Treatability and/or pilot testing are warranted to finalize design considerations, including an initial evaluation to determine the geochemical conditions at the Site.	Capital: Moderate O&M: Moderate	Retained as a potential component of a Site groundwater remedial action alternative.
		Monitored Natural Attenuation	Consideration of this option usually requires modeling and evaluation of COC degradation rates and pathways and predicting COC concentration at down gradient receptor points. Does not achieve Site RAOs.	Readily implementable. The evaluation of natural attenuation is often not straightforward and will require expertise in several technical areas including microbiology/bioremediation, hydrogeology, and geochemistry.	Capital: Moderate O&M: Moderate	Retained as a potential component of a Site groundwater remedial action alternative.
	Chemical Treatment	Permeable Reactive Barriers	Potentially effective method for the destruction or retention of dissolved organic COCs, although the effectiveness of permeable reactive barriers may reduce over time. The reduction in effectiveness could result from biological activity or chemical precipitation, which may limit the permeability of the barrier and therefore require the replacement of the reactive media. Working with heavy equipment results in additional human health risks during installation.	Given the depths of COC impacted alluvial groundwater (in excess of 69 feet), the use of boreholes is considered to provide an advantage over trench installed permeable reactive barriers. Commercially available equipment can be used to advance the boreholes, although measures may be required to limit the impact of heavy equipment on the wetland area.	Capital: High O&M: Moderate to High	Eliminated. Due to concerns regarding its long term effectiveness, difficulties in implementation and high cost.

TABLE 5.1
SUMMARY OF COMPARATIVE ANALYSIS OF FRACTURED BEDROCK REMEDIAL ALTERNATIVES
MISSOURI ELECTRIC WORKS (MEW) SITE

Criteria	Fractured Bedrock Remedial Alternatives	
	Alternative FB-1: No Action	Alternative FB-2: Limited Action
Overall Protection of Human Health	10	40
Compliance with ARARs	10	10
Long-term effectiveness and Permanence	1	3
Reduction of Toxicity, Mobility, or Volume of Chemicals	1	1
Short-term Effectiveness	4	3
Implementability	4	3
Cost	4	3
State Acceptance[a]	-	-
Community Acceptance[a]	-	-
Total	**34**	**63**

Notes:

[a] State and community acceptance will be fully addressed during the public comment period.

Rating scale: 1 = poor; 2 = fair; 3 = good; 4 = very good. High scores are favorable.

'- The mandatory NCP criteria of overall protection and compliance with ARARS has been weighted by a factor of ten.

MEW Site File
3DISC104280

TABLE 5.2

ESTIMATED COSTS TO IMPLEMENT FRACTURED BEDROCK REMEDIAL ALTERNATIVES

MISSOURI ELECTRIC WORKS (MEW) SITE

Criteria		Fractured Bedrock Remedial Alternatives	
		Alternative FB-1: No Action	Alternative FB-2: Limited Action (Accurate to -30% to +50%)
Capital Cost		$0	$0
Annual O&M Cost	2nd Year	$0	$155,719
	4th Year	$0	$74,074
Total Periodic Cost		$0	$24,778
Total Net Present Value		$0	$2,248,453

Notes:

1) "Capital Costs" refers to costs associated with alternative design, construction, installation and start-up. All capital costs are assumed to occur in year zero for discounting purposes.

2) "Annual O&M Costs" are for routine operation, maintenance and monitoring of alternative, and include costs for such items as groundwater well monitoring, remedial system operation and maintenance, removal/disposal of treatment residuals, and ongoing project management and technical support.

3) "Total Net Periodic Costs" are the cumulative net present value costs (with an inflation rate of 3.0% and an annual discount rate of 5.0% for the first 15 years then 4.0% thereafter) which occur during the course of an alternative operation which are not routine annual O&M cost, such as five-year reviews.

4) "Total Present Value" is the total alternative costs (including Capital, O&M, and Periodic Costs) with applied annual discount rate of 5.0% and an inflation rate of 3.0%.

5) Costs are presented as feasibility study level estimates (the period of system operation and final budget costs are subject to design and subsequent detailed cost review).

MEW Site File
3DISC104281

TABLE 5.3
SUMMARY OF COMPARATIVE ANALYSIS OF ALLUVIUM REMEDIAL ALTERNATIVES
MISSOURI ELECTRIC WORKS (MEW) SITE

Criteria	Alluvium Remedial Alternatives				
	Alternative AL-1: No Action	**Alternative AL-2: Limited Action**	**Alternative AL-3: Groundwater Extraction, Treatment and Discharge**	**Alternative AL-4: Enhanced Biodegradation by HRC Injection**	**Alternative AL-5: Monitored Natural Attenuation**
Overall Protection of Human Health and the Environment	10	40	40	40	40
Compliance with ARARs	10	10	40	40	40
Long-term Effectiveness and Permanence	1	3	4	3	3
Reduction of Toxicity, Mobility, or Volume of Chemicals	1	1	2	3	3
Short-term Effectiveness	4	3	1	2	3
Implementability	4	3	1	2	3
Cost	4	3	1	2	3
State Acceptance[a]	-	-	-	-	-
Community Acceptance[a]	-	-	-	-	-
Total	**34**	**63**	**89**	**92**	**95**

Notes:

Notes:

[a] State and community acceptance will be fully addressed during the public comment period.

Rating scale: 1 = poor; 2 = fair; 3 = good; 4 = very good. High scores are favorable.

'- The mandatory NCP criteria of overall protection and compliance with ARARs has been weighted by a factor of ten.

TABLE 5.4
ESTIMATED COSTS TO IMPLEMENT ALLUVIUM REMEDIAL ALTERNATIVES
MISSOURI ELECTRIC WORKS (MEW) SITE

Criteria		Fractured Bedrock Remedial Alternatives				
		Alternative AL-1: No Action	Alternative AL-2: Limited Action (Accurate to -30% to +50%)	Alternative AL-3: Groundwater Extraction, Treatment, and Discharge (Accurate to -30% to +50%)	Alternative AL-4: Enhanced Biodegradation by HRC Injection (Accurate to -30% to +50%)	Alternative AL-5: Monitored Natural Attenuation (Accurate to -30% to +50%)
Capital Cost		$0	$0	$485,692	$0	$0
Annual O&M Cost	2nd Year	$0	$97,324	$412,165	$327,174	$278,347
	4th Year	$0	$46,922	$272,259	$121,995	$134,196
Total Periodic Cost		$0	$24,778	$24,778	$24,778	$24,778
Total Net Present Value		$0	$1,459,393	$8,288,101	$4,815,568	$3,905,536

Notes:

1) "Capital Costs" refers to costs associated with alternative design, construction, installation and start-up. All capital costs are assumed to occur in year zero for discounting purposes.

2) "Annual O&M Costs" are for routine operation, maintenance and monitoring of alternative, and include costs for such items as groundwater well monitoring, remedial system operation and maintenance, removal/disposal of treatment residuals, and ongoing project management and technical support.

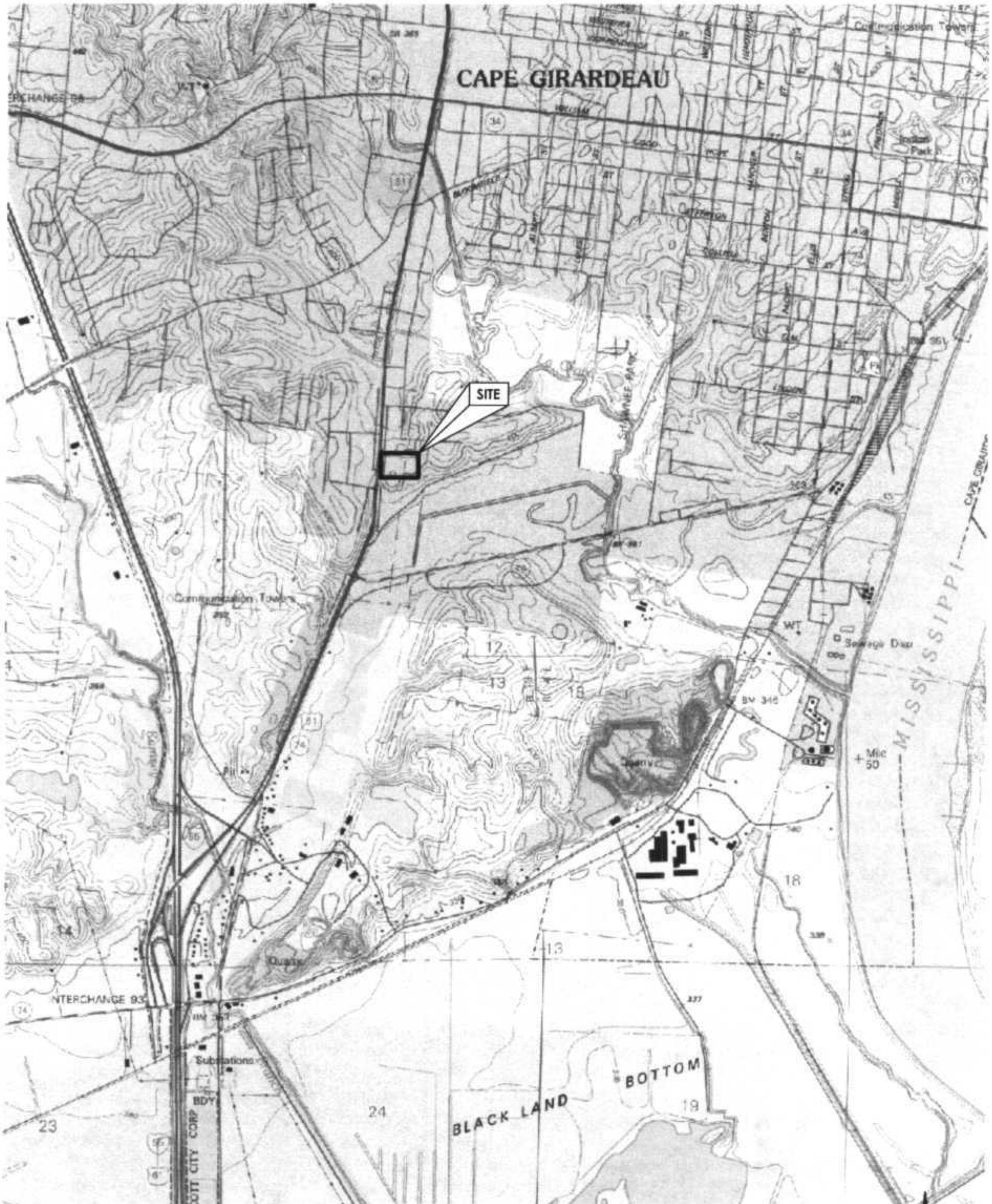
3) "Total Net Periodic Costs" are the cumulative net present value costs (with an inflation rate of 3.0% and an annual discount rate of 5.0% for the first 15 years then 4.0% thereafter) which occur during the course of an alternative operation which are not routine annual O&M cost, such as five-year reviews.

4) "Total Present Value" is the total alternative costs (including Capital, O&M, and Periodic Costs) with applied annual discount rate of 5.0% and an inflation rate of 3.0%.

5) Costs are presented as feasibility study level estimates (the period of system operation and final budget costs are subject to design and subsequent detailed cost review).

Figures

FIGURES



NOTES

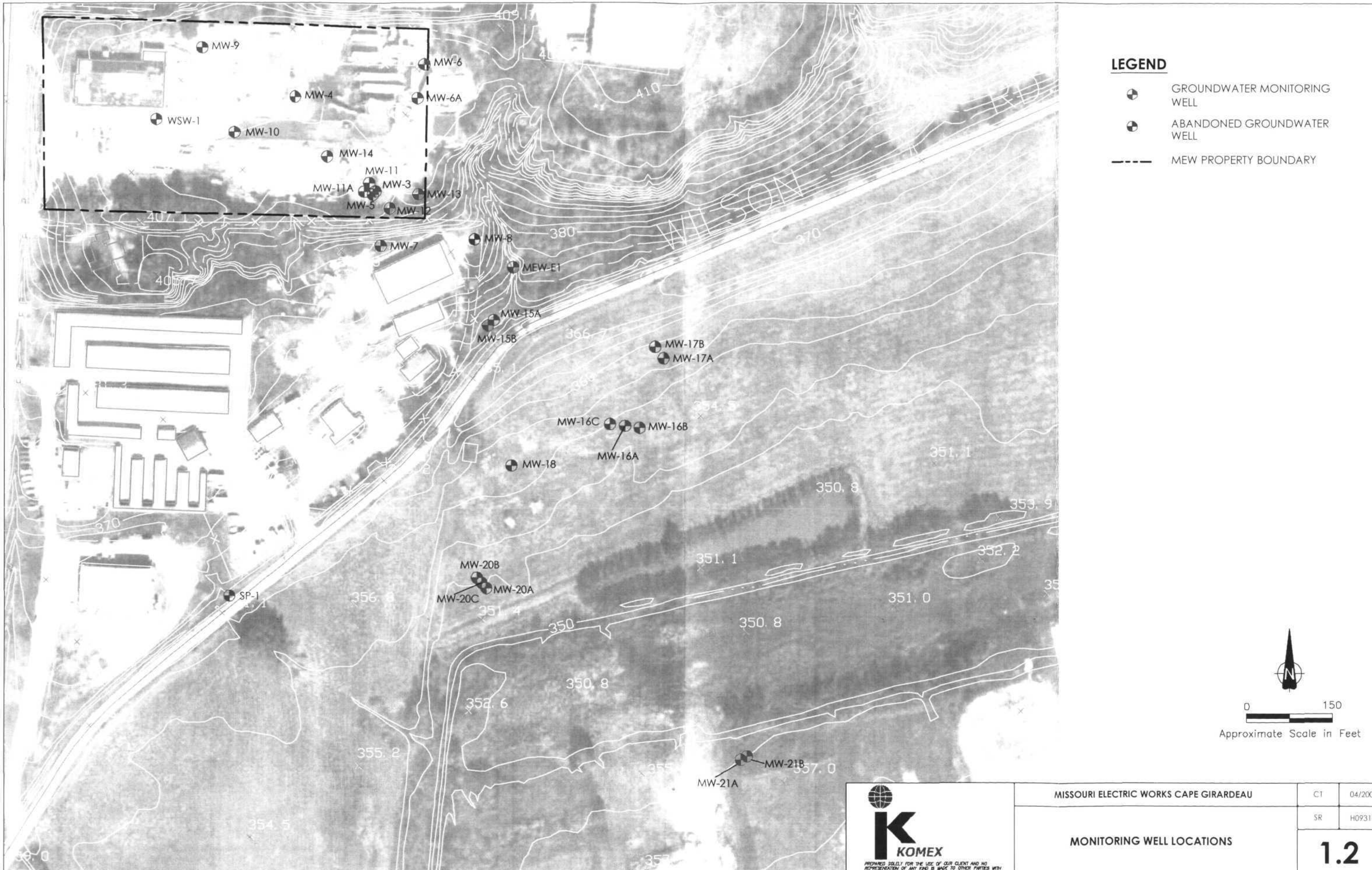
1) BASE MAP FROM USGS 7.5 MINUTE CAPE GIRARDEAU QUADRANGLE (1965, REVISED 1993).

2) ALL LOCATIONS ARE APPROXIMATE.

0 0.5
Approximate Scale in Miles

MEW Site File
3DISC104285

KOMEX	MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
		JR	H0931G
PREPARED SOLELY FOR THE USE OF OUR CLIENT AND NO REPRESENTATION OF ANY KIND IS MADE TO OTHER PARTIES WITH WHICH KOMEX HAS NOT ENTERED INTO A CONTRACT.	SITE LOCATION MAP	1.1	



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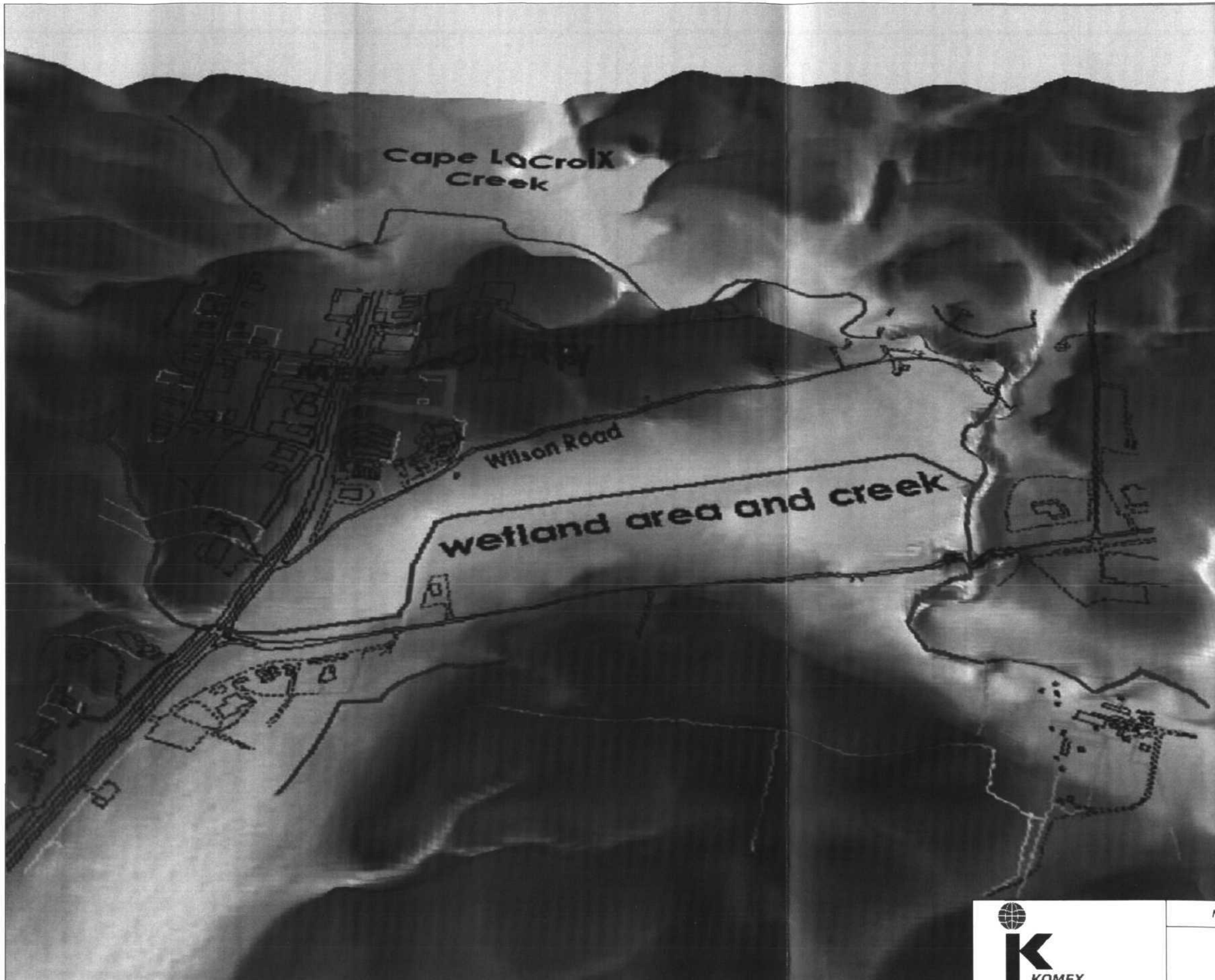

LEGEND

MEW PROPERTY

NOTES

1. View from south.
2. Vertical exaggeration approximately 1.5 times.

NOT TO SCALE

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MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2
GENERAL VIEW ACROSS MEW SITE AREA	SR	H0931G
		1.3

MEW Site File

3DISC104287

LEGEND

GROUNDWATER MONITORING WELL

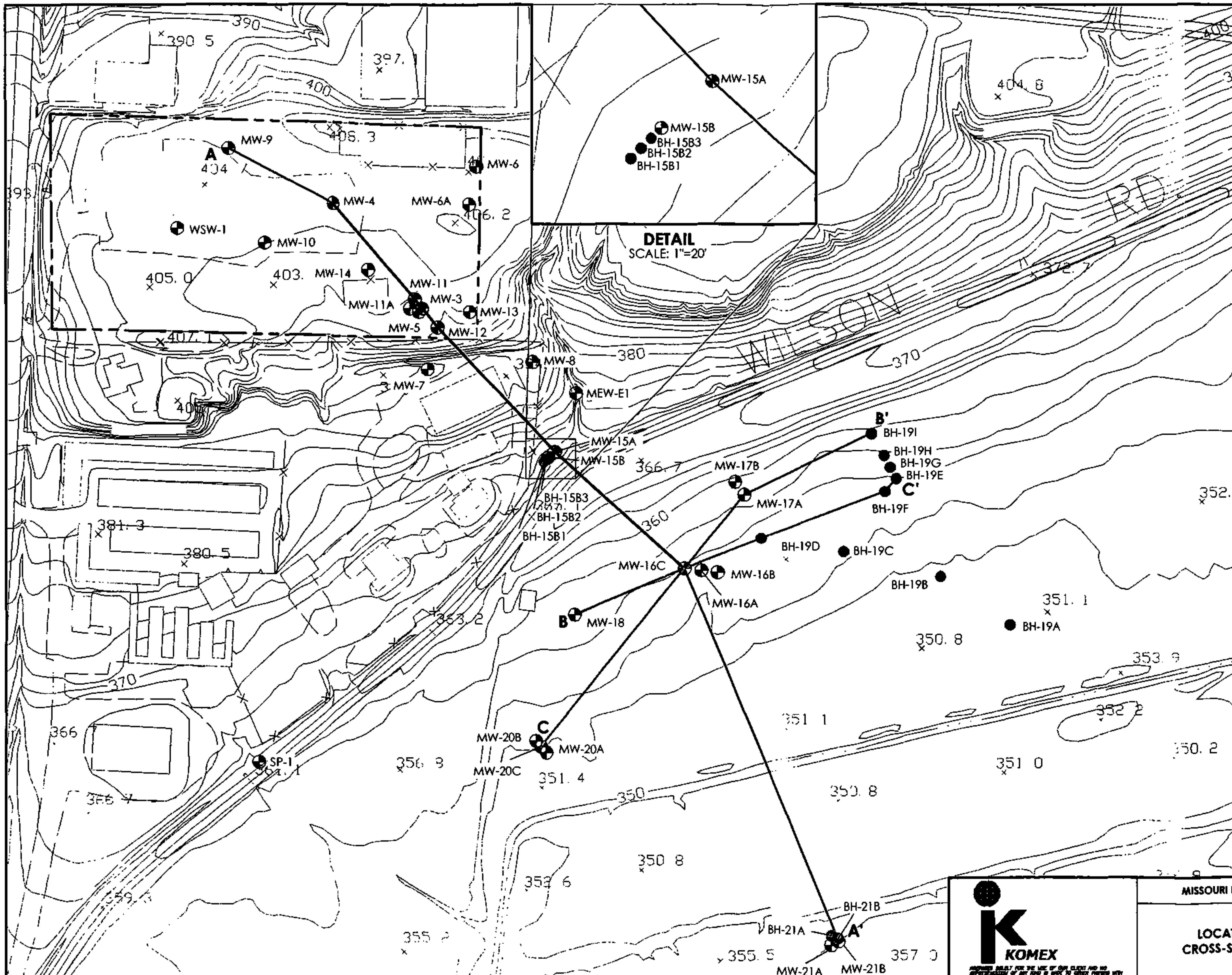
ABANDONED GROUNDWATER WELL

MEW PROPERTY BOUNDARY

SURFACE WATER FLOW PATHWAY AS OBSERVED DURING A STORM EVENT IN JUNE, 2003

0 250
Approximate Scale in Feet

KOMEX	MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
		SR	H0931G
	SURFACE RUNOFF PATHWAYS	1.4	



LEGEND

- GROUNDWATER MONITORING WELL
- ABANDONED GROUNDWATER WELL
- TEST BOREHOLE LOCATION, 2004
- NEW PROPERTY BOUNDARY
- CROSS-SECTION LOCATION A-A'
- CROSS-SECTION LOCATION B-B'
- CROSS-SECTION LOCATION C-C'

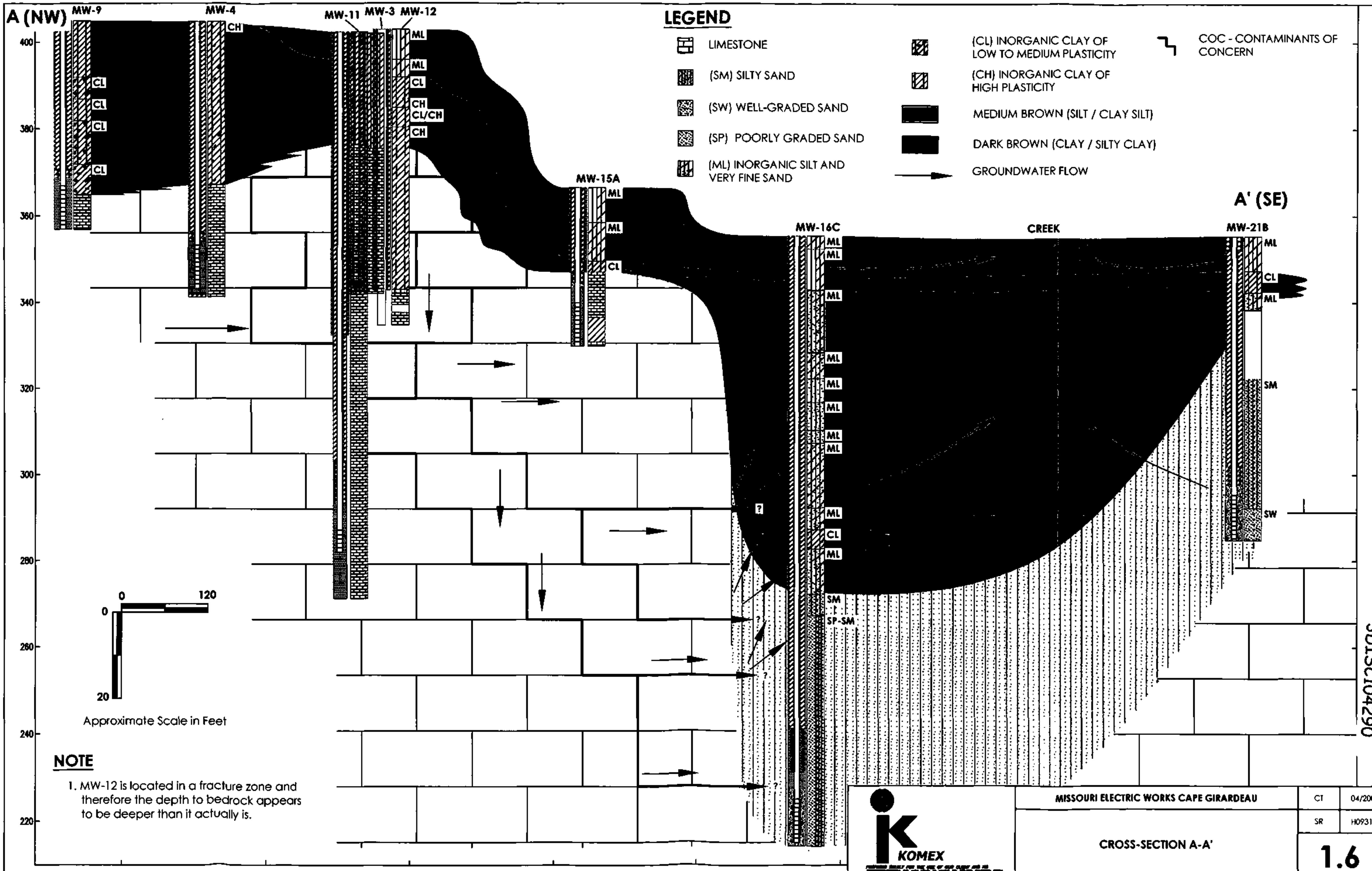
0 150

Approximate Scale in Feet

KOMEX

MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS A-A', B-B', AND C-C'	SR	H0931G
		1.5

MEW Site File
3DISC104289



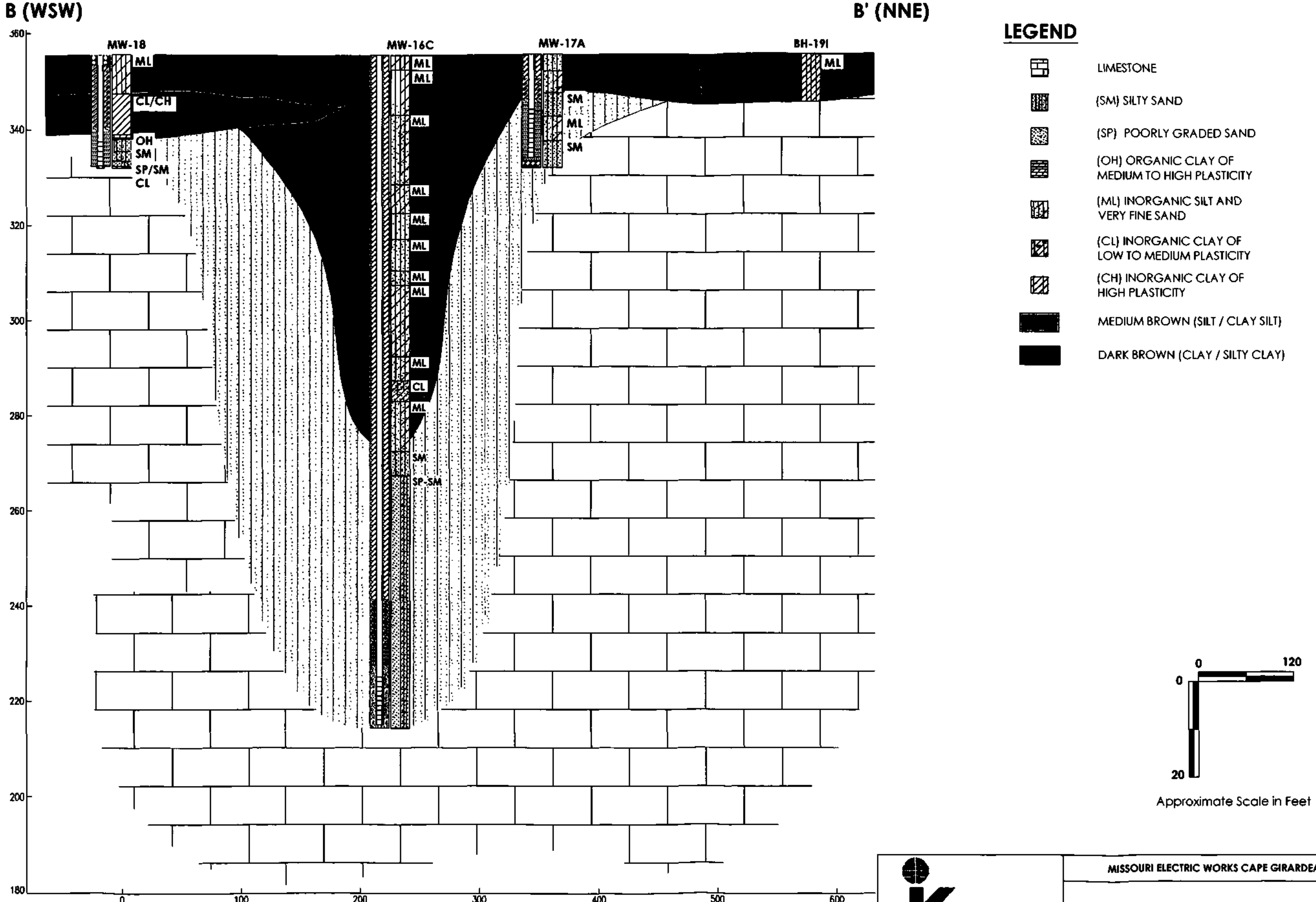
NOTE

1. MW-12 is located in a fracture zone and therefore the depth to bedrock appears to be deeper than it actually is.

KOMEX

MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
	SR	H0931G
CROSS-SECTION A-A'	1.6	

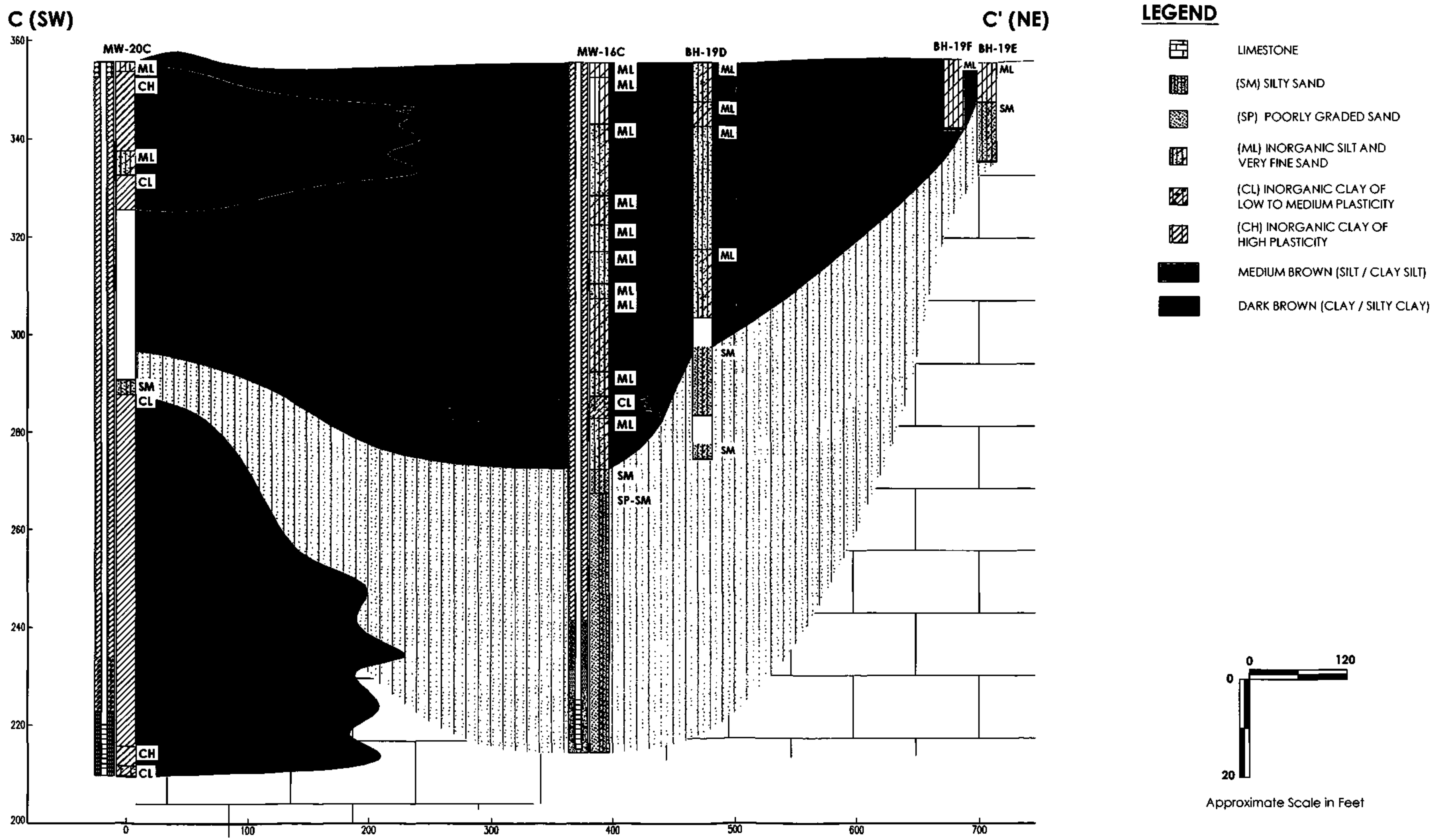
MEW Site File
3DISC104290



KOMEX

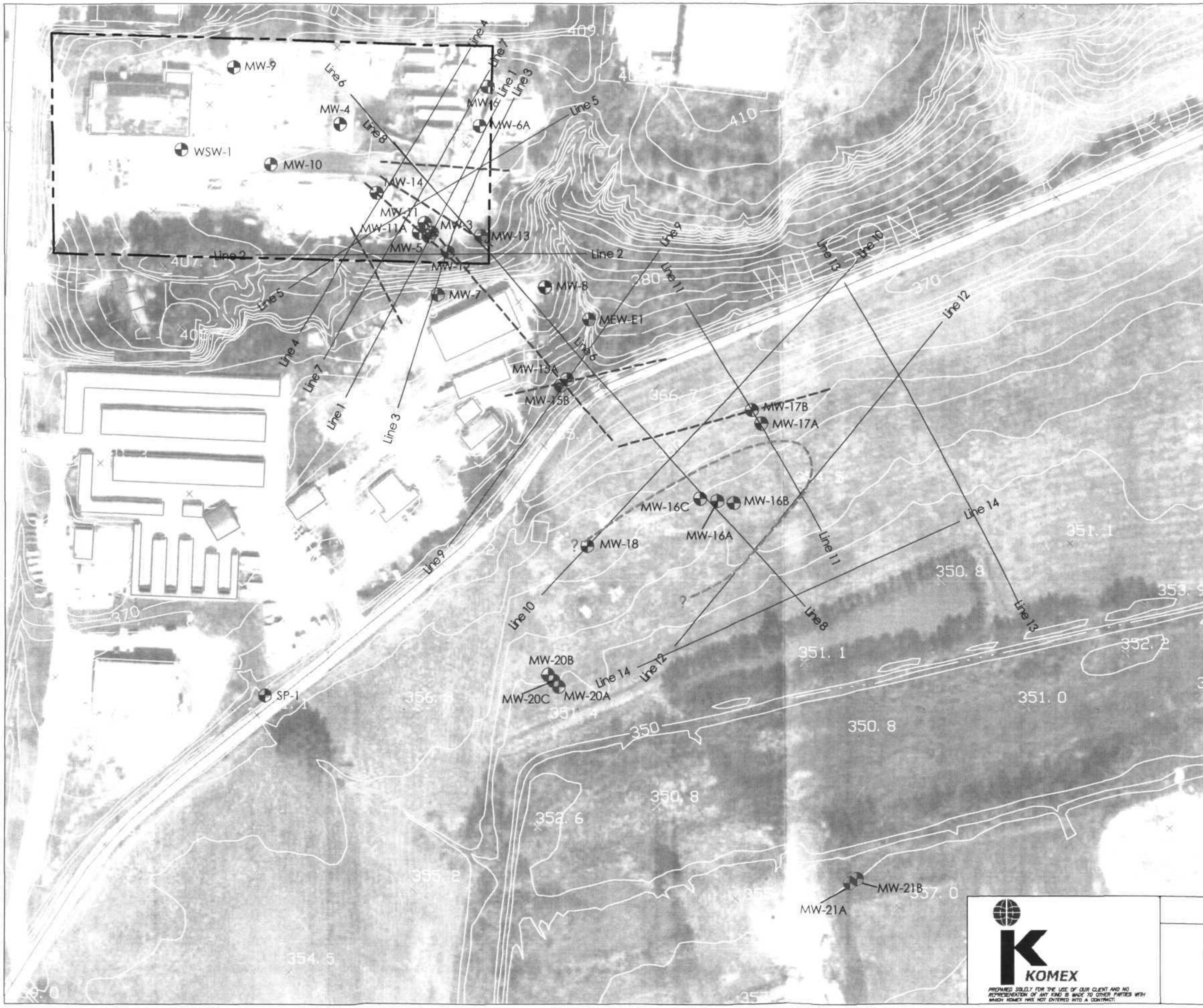
MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
CROSS-SECTION B-B'	SR	H0931G
		1.7

MEW Site File
3DISC104291



MEW Site File
3DISC104292

KOMEX	MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
	CROSS-SECTION C-C'	SR	H0931G
		1.8	



LEGEND

●	GROUNDWATER MONITORING WELL
●	ABANDONED GROUNDWATER WELL
------	INTERPRETED FRACTURE ZONE
——	GEOPHYSICAL SURVEY LINE
— - —	MEW PROPERTY BOUNDARY
------	BEDROCK DEPRESSION

N

0 150

Approximate Scale in Feet

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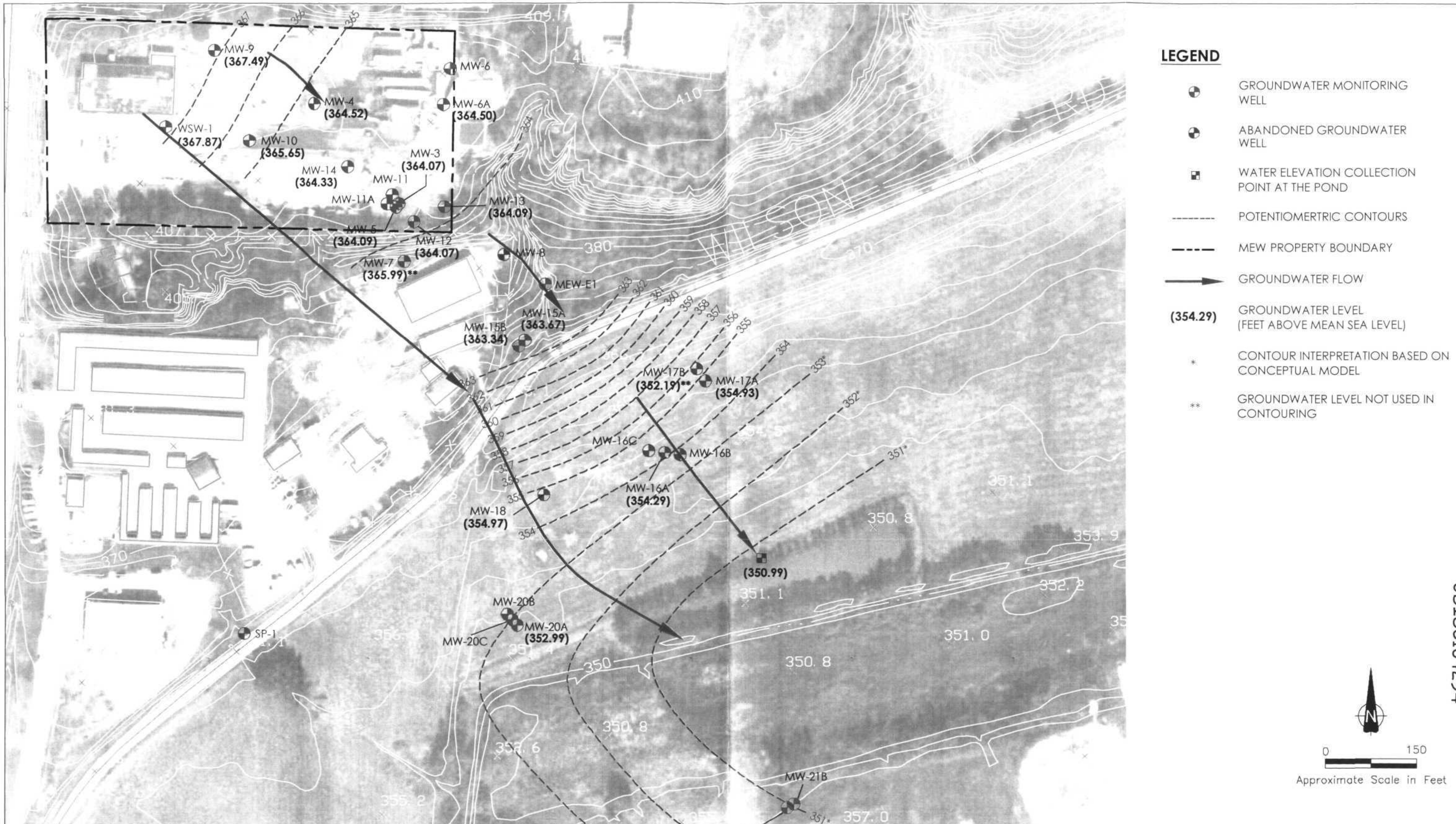
MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
INTERPRETED BEDROCK STRUCTURE AND FRACTURE TRENDS	SR	H0931G
		1.9

MEW Site File
3DISC104293



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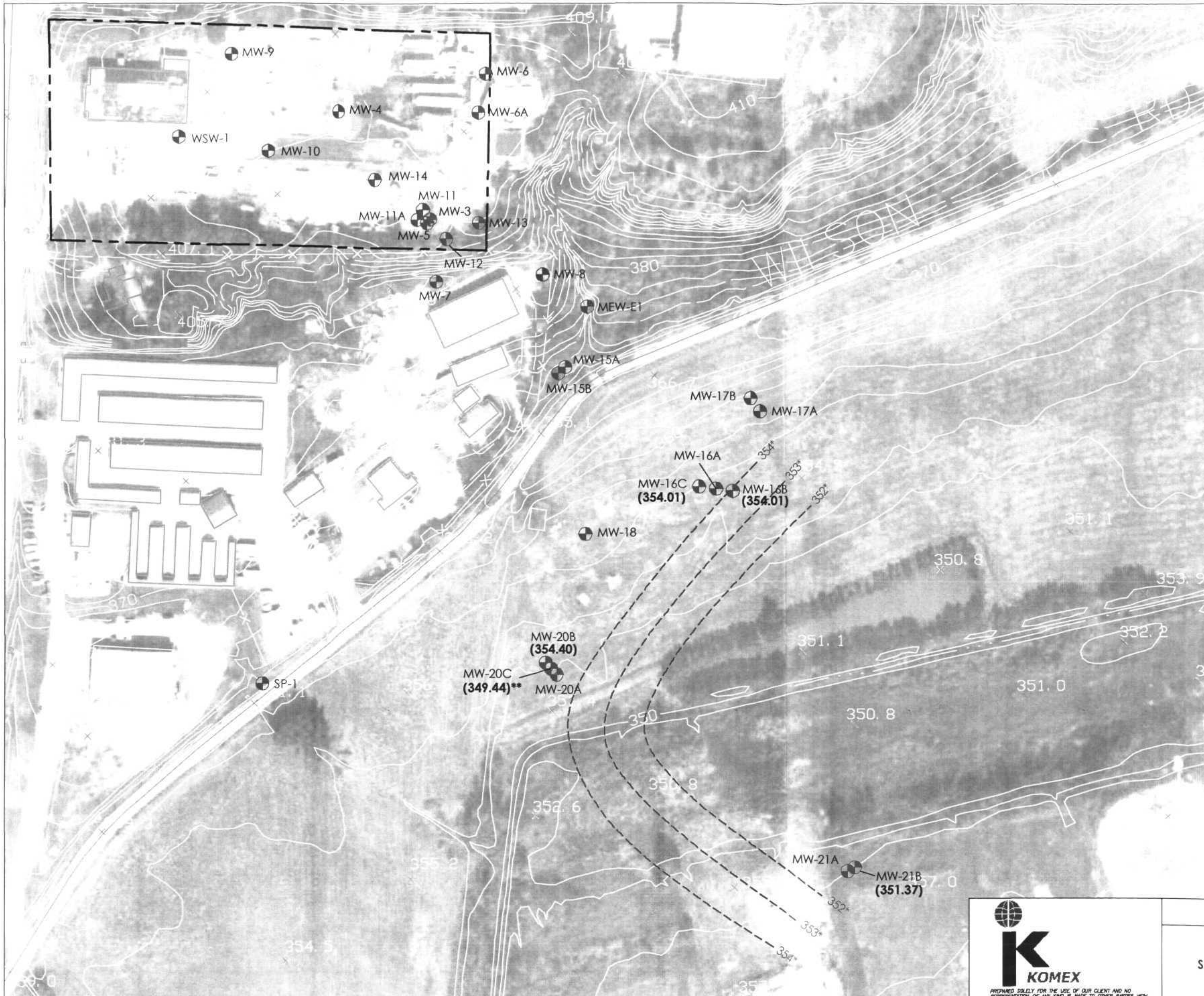
MISSOURI ELECTRIC WORKS CAPE GIRARDEAU

POTENTIOMETRIC SURFACE FOR WELLS SCREENED <100 FEET BGS IN BEDROCK AND <25 FEET BGS IN ALLUVIUM FOR NOVEMBER 15, 2004

CT 04/2005
SR H0931G

1.10

MEW Site File
3DISC104294



LEGEND

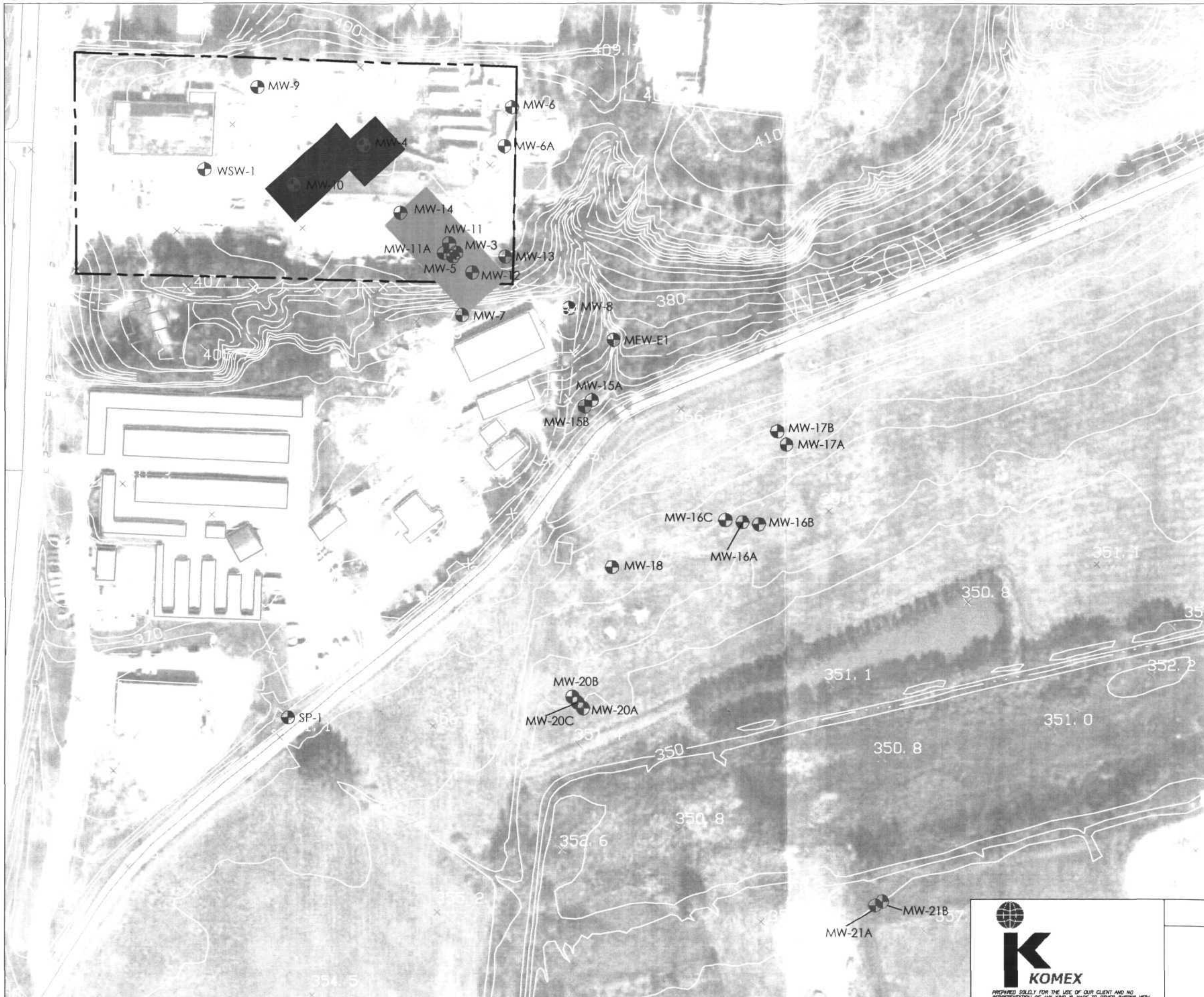
(symbol)	GROUNDWATER MONITORING WELL
(symbol)	ABANDONED GROUNDWATER MONITORING WELL
--------	POTENTIOMETRIC CONTOURS
— - - —	MEW PROPERTY BOUNDARY
(351.37)	GROUNDWATER LEVEL (FEET ABOVE MEAN SEA LEVEL)
*	CONTOUR INTERPRETATION BASED ON CONCEPTUAL MODEL
**	GROUNDWATER LEVEL NOT USED IN CONTOURING

N

0 150
Approximate Scale in Feet

KOMEX

MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
POTENTIOMETRIC SURFACE FOR WELLS SCREEND 50 TO 150 FEET BGS IN ALLUVIAL SEDIMENTS FOR NOVEMBER 15, 2004	SR	H0931G
		1.11



LEGEND

- GROUNDWATER MONITORING WELL
- ABANDONED GROUNDWATER WELL
- MEW PROPERTY BOUNDARY

NOTES

1) SOURCE AREA 1 SHOWN IN GREEN.
2) SOURCE AREA 2 SHOWN IN BLUE.

N

0 50
Approximate Scale in Meters

KOMEX

MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
LOCATIONS OF MODELED SOURCE AREAS	SR	H0931G
		1.12

LEGEND

- GROUNDWATER MONITORING WELL
- ABANDONED GROUNDWATER MONITORING WELL
- MEW PROPERTY BOUNDARY
- 14 CONCENTRATIONS ABOVE MAXIMUM CONTAMINANT LEVEL

NOTES

1. 1,1-DCE-16 = concentration in μg/L
2. N/D = non-detection of constituents of concern
3. MW-19 was not installed.
4. MW-1 and MW-2 have been abandoned, but the exact location is not known.
5. N/S = not sampled
6. μg/L = micrograms per liter

0 150
Approximate Scale in Feet

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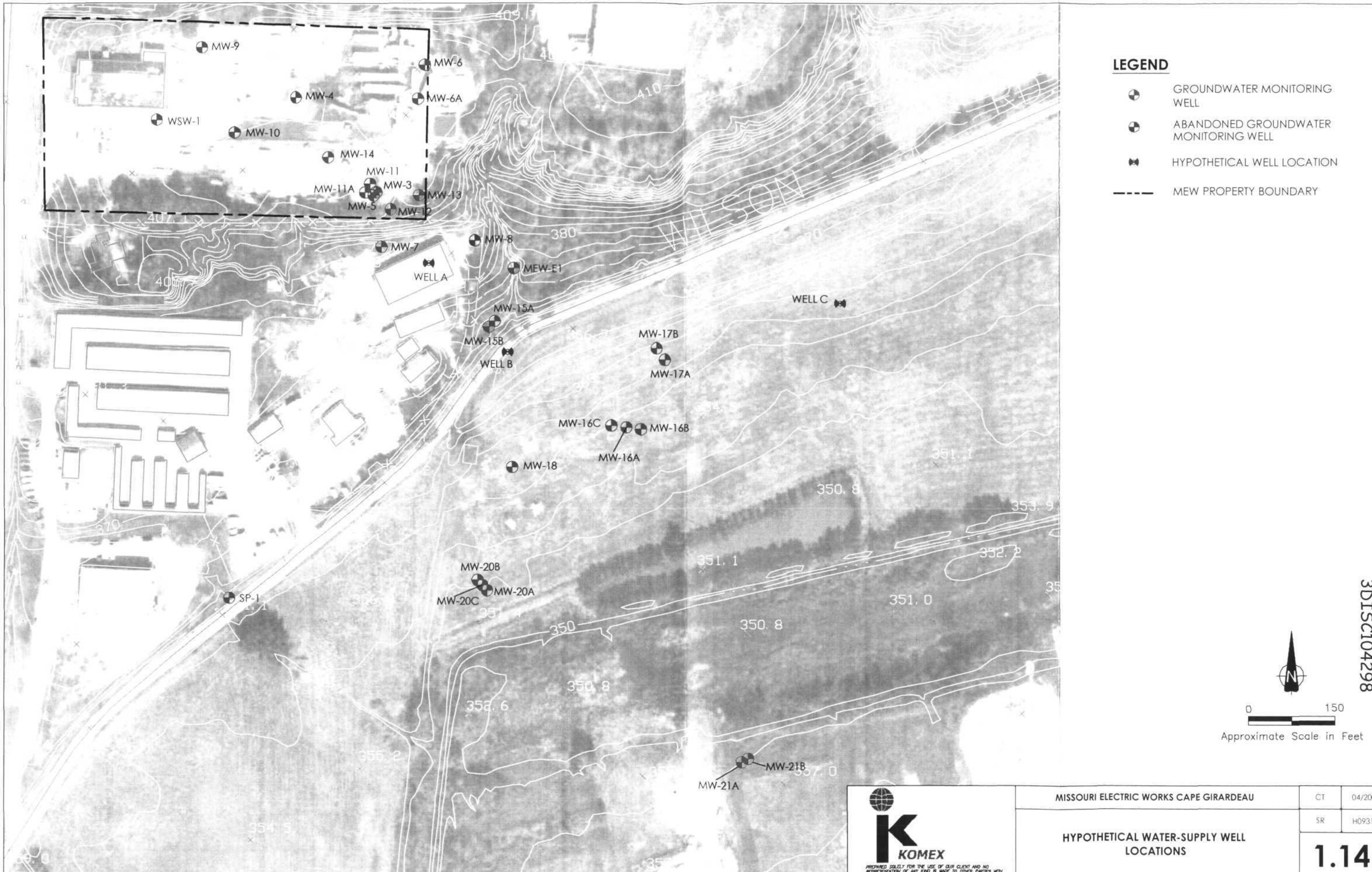
MISSOURI ELECTRIC WORKS CAPE GIRARDEAU

GROUNDWATER CONSTITUENTS OF POTENTIAL CONCERN CONCENTRATIONS FOR NOVEMBER 2004

CT 04/2005
SR H0931G

1.13



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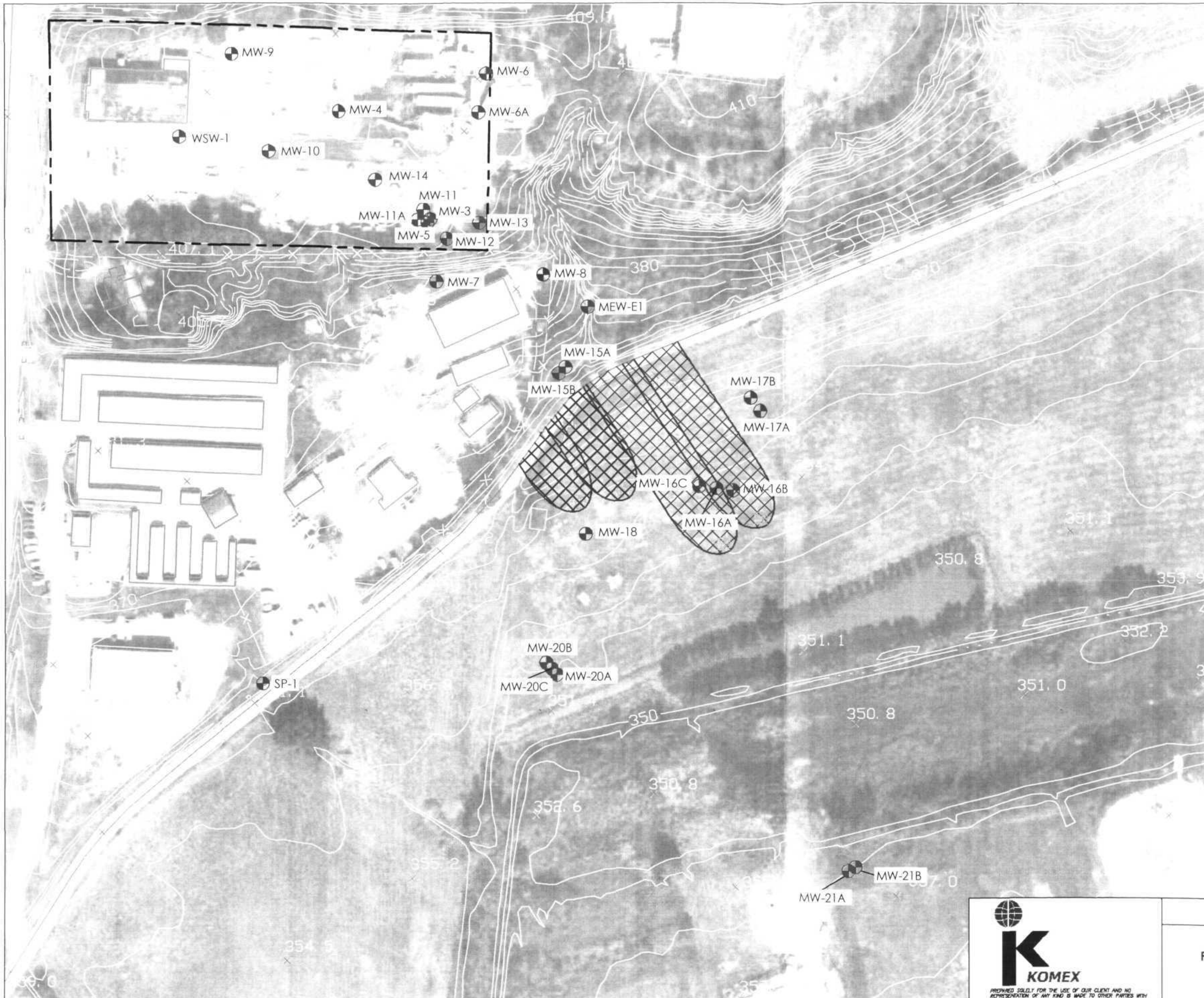
MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
HYPOTHETICAL WATER-SUPPLY WELL LOCATIONS	SR	H0931G
		1.14



LEGEND

GROUNDWATER MONITORING WELL

ABANDONED GROUNDWATER MONITORING WELL

LOCATION OF PROPOSED GROUNDWATER EXTRACTION WELLS

MEW PROPERTY BOUNDARY

NOTE

1. MEW- Missouri Electric Works

0 150

Approximate Scale in Feet

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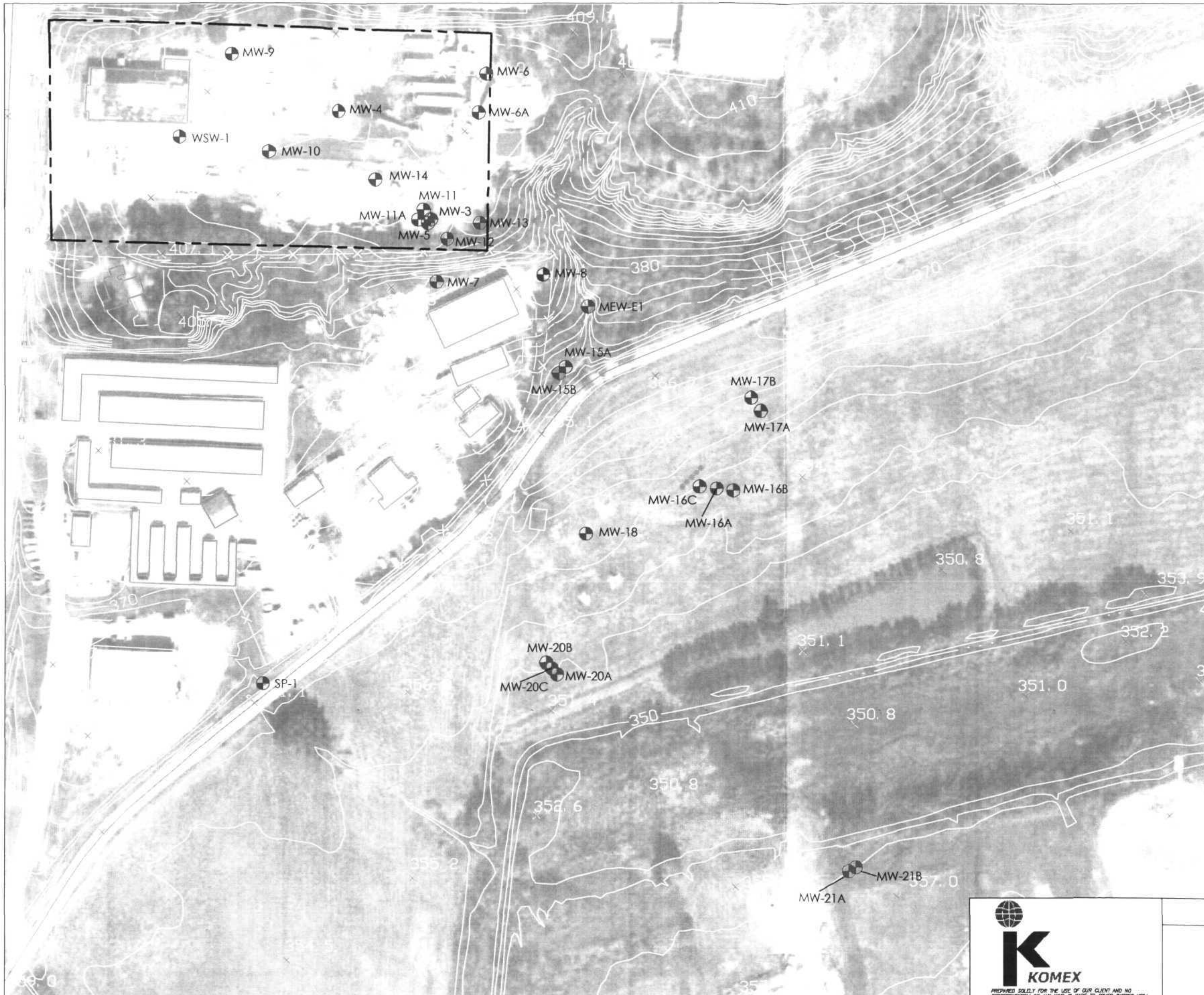
MISSOURI ELECTRIC WORKS CAPE GIRARDEAU

PROPOSED GROUNDWATER EXTRACTION WELLS AND CAPTURE ZONES

CT 04/2

SR H0931G

4.1



LEGEND

- GROUNDWATER MONITORING WELL
- ABANDONED GROUNDWATER MONITORING WELL
- MEW PROPERTY BOUNDARY
- HRC INJECTION POINT

NOTE

1. HRC = hydrogen release compound

MEW Site File
3DISC104300

KOMEX

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MISSOURI ELECTRIC WORKS CAPE GIRARDEAU	CT	04/2005
PROPOSED HRC INJECTION WELLS	SR	H0931G
		4.2

A

APPENDIX A

EPA/ROD/R07-90/038
1990

EPA Superfund
Record of Decision:

MISSOURI ELECTRIC WORKS
EPA ID: MOD980965982
OU 01
CAPE GIRARDEAU, MO
09/28/1990

SOIL/SEDIMENT CONTAMINATION

- EXCAVATE ALL SOILS AND SEDIMENTS WITH PCB CONCENTRATIONS GREATER THAN 10 PARTS PER MILLION (PPM) TO A DEPTH OF 4 FEET AND SOILS BELOW THAT DEPTH WITH PCB CONCENTRATIONS GREATER THAN 100 PPM;

- INCINERATE ONSITE THE EXCAVATED PCB-CONTAMINATED SOILS AND SEDIMENTS;

- MONITOR AT LEAST DAILY THE EMISSIONS FROM THE INCINERATOR, BOTH ASH AND GASES; AND,

- BACKFILL THE EXCAVATED AREAS WITH THE ASH AND CLEAN SOIL.

GROUND WATER CONTAMINATION

- INSTALL SIX TO TEN EXTRACTION WELLS;

- EXTRACT GROUND WATER AND STORE IT IN A TANK ONSITE;

- PROCESS THE STORED WATER THROUGH AN AIR-STRIPPING TOWER;

- PROCESS THE VAPOR-PHASE AFTER AIR-STRIPPING THROUGH AN ACTIVATED CARBON ADSORPTION UNIT, DISCHARGE THE TREATED WATER TO THE SURFACE OR TO THE PUBLICLY OWNED TREATMENT WORKS (POTW); AND,

- MONITOR QUARTERLY THE EFFECTIVENESS OF THE GROUND WATER TREATMENT SYSTEM.

STATUTORY DETERMINATIONS

THE SELECTED REMEDY IS PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT, COMPLIES WITH FEDERAL AND STATE REQUIREMENTS THAT ARE APPLICABLE OR RELEVANT AND APPROPRIATE (ARARS) TO THIS REMEDIAL ACTION, AND IS COST-EFFECTIVE. THE REMEDY SATISFIES THE STATUTORY PREFERENCE FOR REMEDIES THAT EMPLOY TREATMENT AND REDUCE THE TOXICITY, MOBILITY, OR VOLUME AS A PRINCIPAL ELEMENT AND UTILIZE PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE.

THIS REMEDY WILL NOT RESULT IN HAZARDOUS SUBSTANCES REMAINING ONSITE ABOVE HEALTH-BASED LEVELS. HOWEVER, BECAUSE HAZARDOUS SUBSTANCES WILL BE LEFT ONSITE AT LEVELS THAT WILL REQUIRE LIMITED USES OF AND RESTRICTED EXPOSURE TO THE SITE, A REVIEW OF THE REMEDIAL ACTIONS WILL BE MADE NO LESS OFTEN THAN EVERY FIVE YEARS AFTER INITIATION OF THE REMEDIAL ACTION.

MORRIS KAY DATE: 09/28/90
REGIONAL ADMINISTRATOR
US EPA, REGION VII

#SNLD

1.0 SITE NAME, LOCATION, AND DESCRIPTION

MISSOURI ELECTRIC WORKS, INC., IS LOCATED ON A 6.4-ACRE TRACT ADJACENT TO US HIGHWAY 61 (SOUTH KINGS HIGHWAY) IN A PREDOMINATELY COMMERCIAL/INDUSTRIAL AREA OF CAPE GIRARDEAU, MISSOURI. THE MISSOURI ELECTRIC WORKS (MEW) SITE INCLUDES ALL AREAS THAT HAVE BEEN IDENTIFIED AS HAVING PCB CONTAMINATION. THE APPROXIMATE EXTENT OF THE MEW SITE IS PRESENTED IN FIGURE 1.

THE MEW SITE IS SITUATED APPROXIMATELY 1.6 MILES WEST OF THE MISSISSIPPI RIVER IN THE HILLS ALONG THE VALLEY WALL JUST WEST OF THE MISSISSIPPI RIVER FLOOD PLAIN. INTERMITTENT RUNOFF CHANNELS EMANATE FROM THE NORTH, SOUTH AND EAST BOUNDARIES OF THE MEW PROPERTY AND EVENTUALLY DRAIN INTO THE CAPE LACROIX CREEK LOCATED 0.7 MILES EAST OF THE SITE. THE CAPE LACROIX CREEK FLOWS 1.1 MILES TO THE SOUTHEAST WHERE IT ENTERS THE MISSISSIPPI RIVER. THE MEW PROPERTY IS BOUNDED ON THE NORTH BY RETAIL AND WAREHOUSE PROPERTIES, ON THE SOUTH BY A RESIDENCE, COMMERCIAL STORAGE AND A CONSTRUCTION COMPANY, AND ON THE EAST BY A WAREHOUSE. A WETLAND HAS BEEN IDENTIFIED APPROXIMATELY 700 FEET SOUTH OF THE MEW PROPERTY. FIGURE 2 INDICATES THE APPROXIMATE LOCATION OF THE WETLAND IN RELATION TO THE MEW SITE AND THE CITY OF CAPE GIRARDEAU.

#SHEA

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 SITE HISTORY

MISSOURI ELECTRIC WORKS, INC., SELLS, SERVICES, AND REMANUFACTURES TRANSFORMERS, ELECTRIC MOTORS, AND ELECTRICAL EQUIPMENT CONTROLS. DURING PAST OPERATIONS, MISSOURI ELECTRIC WORKS, INC., REPORTEDLY RECYCLED MATERIALS FROM OLD UNITS, SELLING COPPER WIRE AND REUSING THE DIELECTRIC FLUIDS FROM THE TRANSFORMERS. THE SALVAGED TRANSFORMER OIL WAS FILTERED THROUGH FULLER'S EARTH FOR REUSE. AN ESTIMATED 90 PERCENT OF THE OIL WAS RECYCLED.

MISSOURI ELECTRIC WORKS, INC., HAS BEEN AT ITS PRESENT LOCATION SINCE 1953. ACCORDING TO BUSINESS RECORDS OBTAINED FROM MISSOURI ELECTRIC WORKS, INC., MORE THAN 16,000 TRANSFORMERS HAVE BEEN REPAIRED OR SCRAPPED AT THE SITE DURING THIS TIME. THE TOTAL AMOUNT OF TRANSFORMER OIL THAT WAS NOT RECYCLED DURING THIS PERIOD IS ESTIMATED TO BE 28,000 GALLONS. IN 1984, APPROXIMATELY 5,000 GALLONS OF WASTE OIL, IN DRUMS, WAS REMOVED BY A CONTRACTOR.

INDUSTRIAL SOLVENTS WERE USED TO CLEAN THE ELECTRICAL EQUIPMENT BEING REPAIRED OR SERVICED. SOLVENTS WERE REUSED UNTIL THEY WERE NO LONGER EFFECTIVE. SPILLS AND DISPOSAL OF SPENT SOLVENTS APPARENTLY OCCURRED ON THE MEW PROPERTY.

THE MEW PLANT AND GENERAL OFFICE OCCUPY A BUILDING LOCATED ON THE WEST END OF THE PROPERTY. TO THE EAST OF THE BUILDING AND CONCRETE PAD IS A GRAVEL AREA OF APPROXIMATELY 150 BY 120 FEET USED FOR TRANSFORMER STORAGE. PORTIONS OF THE SITE ARE LITTERED WITH VARIOUS OBJECTS INCLUDING OLD TRANSFORMERS, EMPTY DRUMS, OLD PALLETS AND TRASH. THE MEW PROPERTY AND ADJACENT PROPERTIES HAVE BEEN FOUND TO BE CONTAMINATED WITH POLYCHLORINATED BIPHENYLS (PCBS), SPECIFICALLY AROCLOR 1260. THIS PCB CONTAMINATION IS APPARENTLY THE RESULT OF PAST HANDLING AND STORAGE PROCEDURES OF PCB-CONTAINING TRANSFORMER FLUIDS.

2.2 SITE INVESTIGATIONS

THE MISSOURI DEPARTMENT OF NATURAL RESOURCES (MDNR) INSPECTED THE MEW FACILITY IN OCTOBER 1984 AND DISCOVERED 102 55-GALLON DRUMS CONTAINING TRANSFORMER OIL THAT WERE BEING STORED ON THE MEW PROPERTY. SOME OF THE DRUMS WERE LEAKING. A SAMPLE OF THE OIL- STAINED SOIL WAS OBTAINED BY MDNR FOR ANALYSIS AND FOUND TO CONTAIN 110 PARTS PER MILLION (PPM) POLYCHLORINATED BIPHENYLS (PCBS). A SAMPLE OF OIL-STAINED SURFACE WATER WAS TAKEN BY MDNR. THE ANALYTICAL RESULTS FOR THE WATER SAMPLE INDICATED A PCB CONCENTRATION OF 110 MICROGRAMS PER LITER (UG/L) OR PARTS PER BILLION (PPB).

AN INSPECTION BY THE ENVIRONMENTAL PROTECTION AGENCY (EPA) DURING NOVEMBER 1984, PURSUANT TO THE TOXIC SUBSTANCES CONTROL ACT (TSCA), FOUND THAT MEW HANDLING AND STORAGE PROCEDURES FOR OILS CONTAINING OR CONTAMINATED WITH PCBS DID NOT CONFORM TO THE REGULATIONS. TWO SOIL SAMPLES AND ONE SAMPLE OF STORED OIL WERE OBTAINED. PCBS WERE DETECTED IN THE SOIL SAMPLES AT CONCENTRATIONS OF 310 AND 21,000 MILLIGRAMS PER KILOGRAM (MG/KG) OR PARTS PER MILLION (PPM). THE OIL CONTAINED 1,200 PPM PCBS.

ADDITIONAL AND MORE EXTENSIVE SITE INVESTIGATIONS OF THE MEW FACILITY AND ADJACENT PROPERTIES WERE PERFORMED BY EPA CONTRACTORS BETWEEN OCTOBER 1985 AND JUNE 1987. THESE INVESTIGATIONS INDICATED THAT PCB CONTAMINATION IN SURFACE SOILS AT THE FACILITY WAS EXTENSIVE (WITH PCB CONCENTRATIONS AS HIGH AS 58,000 PPM); THAT SHALLOW SUBSURFACE SOILS AT THE SITE WERE CONTAMINATED TO A LESSER EXTENT; THAT OFFSITE MIGRATION OF PCB-CONTAMINATED SOILS HAD OCCURRED ALONG DRAINAGE PATHS; THAT MEASURABLE LEVELS OF PCBS WERE PRESENT ONSITE AND ON NEARBY OFFSITE BUILDING WALLS; AND THAT MEASURABLE CONCENTRATIONS OF AIRBORNE PCBS WERE PRESENT. ONE ROUND OF SAMPLING FROM ONSITE MONITORING WELLS INDICATED THAT SHALLOW GROUND WATER CONTAINED LOW CONCENTRATIONS OF PCBS; HOWEVER, LATER SAMPLING OF THE WELLS BY EPA AND MORE DETAILED ANALYSIS DURING THE REMEDIAL INVESTIGATION (RI) DID NOT DETECT PCBS IN THE GROUND WATER AND IT WAS CONCLUDED THAT THE EARLIER RESULTS WERE PROBABLY THE RESULT OF SAMPLING ERRORS. THESE INVESTIGATIONS, AS WELL AS OTHER INVESTIGATIONS ARE SUMMARIZED IN MORE DETAIL IN THE RI REPORT.

EPA OBTAINED WIPE SAMPLES OF THE EXTERIOR OF SEVERAL BUILDINGS LOCATED IN THE VICINITY OF MEW DURING AUGUST 1989. ANALYTICAL DATA FROM THESE SAMPLES INDICATED THAT NO PCBS HAD MIGRATED TO THE BUILDINGS WEST OF HIGHWAY 61.

THE MISSOURI ELECTRIC WORKS STEERING COMMITTEE (MEWSC), A GROUP OF POTENTIALLY RESPONSIBLE PARTIES FOR THE SITE, CONDUCTED A REMEDIAL INVESTIGATION (RI) PURSUANT TO AN ADMINISTRATIVE ORDER ON CONSENT ISSUED BY EPA. THE FIELD ACTIVITIES WERE CONDUCTED FROM SEPTEMBER 1989 TO MARCH 1990. THE FINDINGS OF THESE ACTIVITIES ARE SUMMARIZED BELOW:

1. SOILS

PCBS ADSORBED ONTO THE NEAR-SURFACE SOILS HAVE BEEN TRANSPORTED ONTO SURROUNDING PROPERTIES PRIMARILY VIA STORM WATER RUNOFF. THIS CONTAMINATION IS LOCATED PRIMARILY ALONG DRAINAGE PATHWAYS WITH THE LEVELS DECREASING WITH GREATER DISTANCE FROM MEW. THE HIGHEST LEVELS OF PCBS OBSERVED IN ANY OFFSITE SAMPLE (2,030 PPM) WAS FOUND IN A DRAINAGE CHANNEL AT THE BOUNDARY BETWEEN THE MEW PROPERTY AND THE MORRILL PROPERTY.

GEOSTATISTICAL MODELING OF THE DATA COLLECTED DURING THE RI WAS USED TO DETERMINE THE AREAL EXTENT OF PCB CONTAMINATION ON THE SITE AND SURROUNDING AREAS. THE TOTAL AREA OF SURFACE SOILS AND SEDIMENT WITH PCB CONCENTRATIONS OF 10 PPM OR GREATER IS APPROXIMATELY 295,000 SQUARE FEET OR 6.8 ACRES (EXCLUDING AREAS COVERED BY PAVING AND STRUCTURES). THE LIMITS OF THE 10 PPM ISOCONCENTRATION CONTOUR ARE SHOWN IN FIGURE 3. IT IS ESTIMATED THAT THE AREA CONTAMINATED WITH PCB CONCENTRATIONS OF 500 PPM OR GREATER IS OVER FOUR ACRES. THE UPPER BOUND 95 PERCENTILE CONFIDENCE LEVEL OF THE ARITHMETIC MEAN IS APPROXIMATELY 5,000 PPM FOR ALL SAMPLES TAKEN AT THE SITE.

PCB CONTAMINATION WAS FOUND AT DEPTH IN THE TRANSFORMER STORAGE AND DEBRIS BURIAL AREAS. ADDITIONALLY, VOLATILE ORGANIC COMPOUND (VOC) CONTAMINATION WAS DETECTED IN SOILS DOWN TO 2.5 FEET BELOW THE GROUND SURFACE SOUTH AND EAST OF THE MEW BUILDING, THE TRANSFORMER STORAGE AREA AND THE DEBRIS BURIAL AREA.

2. GROUND WATER

PCBS WERE NOT DETECTED IN ANY OF THE GROUND WATER SAMPLES OBTAINED DURING PHASES I AND II OF THE RI. WATER SAMPLES OBTAINED DURING PHASE III WERE NOT TESTED FOR PCBS. VOCS, PARTICULARLY 1,1-DICHLOROETHANE, TRANS-1,2-DICHLOROETHENE, CHLOROBENZENE, AND TRICHLOROETHENE, WERE DETECTED IN MONITORING WELL NOS. 3 AND 5 AT CONCENTRATIONS IN THE PART PER BILLION (PPB) RANGE. THE HIGHEST CONCENTRATION OF TOTAL VOCS DETECTED WAS 320 PPB. ANALYTICAL DATA FROM ADDITIONAL SAMPLING SHOWED THAT VOC-CONTAMINATED GROUND WATER HAS

MIGRATED BEYOND THE MEW PROPERTY BOUNDARIES IN ONE OF THE TWO OFFSITE WELLS (SEE FIGURE 4).

GROUND WATER IN THE VICINITY OF THE SITE IS APPARENTLY FLOWING TO THE EAST, NORTHEAST, AND SOUTHEAST FROM THE SITE, AS THE MEW PROPERTY IS THE "HIGH" POINT IN THE IMMEDIATE AREA. THESE GROUND WATER FLOW DIRECTIONS ARE BASED ON LIMITED OBSERVATIONS.

REGIONAL GEOLOGIC AND HYDROGEOLOGIC INFORMATION IN THE POSSESSION OF THE MISSOURI DIVISION OF GEOLOGY AND LAND SURVEY (DGLS) INDICATES THAT THE LIMESTONE BEDROCK EXTENDS TO A DEPTH OF ABOUT 1,000 FEET WITHOUT A SIGNIFICANT SHALE LAYER BEING PRESENT. THIS MEANS THAT THERE IS NOT A BARRIER OR CONFINING LAYER PRESENT TO PREVENT THE DOWNWARD MIGRATION OF CONTAMINATION IN THE BEDROCK AQUIFER ONCE THE CONTAMINATION REACHES GROUND WATER. SOME OF THE VOC CONTAMINANTS ARE KNOWN TO BE "SINKERS", I.E., THEY ARE HEAVIER THAN WATER AND TEND TO SINK THROUGH WATER TO A CONFINING LAYER.

NO USERS OF THE UPPER PORTIONS OF THE BEDROCK AQUIFER WERE IDENTIFIED. THIS DOES NOT MEAN THAT USERS DO NOT EXIST. USERS OF LOWER PORTIONS OF THE BEDROCK AQUIFER HAVE BEEN IDENTIFIED.

3. SURFACE WATER AND ADJACENT WETLAND AREA

SURFACE WATER SAMPLES WERE COLLECTED IN THE DRAINAGE DITCH ALONG WILSON ROAD AND IN THE WETLAND AREA IMMEDIATELY SOUTH OF WILSON ROAD. NO PCBS WERE DETECTED IN ANY OF THOSE SAMPLES.

2.3 ENFORCEMENT ACTIVITIES

AN ADMINISTRATIVE ORDER WAS ISSUED TO MISSOURI ELECTRIC WORKS, INC., BY EPA PURSUANT TO S106 OF CERCLA ON AUGUST 2, 1988. THIS ORDER REQUIRED MISSOURI ELECTRIC WORKS, INC., TO PERFORM SEVERAL RESPONSE ACTIONS, SPECIFICALLY: TO NOTIFY THE PUBLIC OF THE SITE CONTAMINATION; MINIMIZE THE EXPOSURE OF THE PUBLIC AND EMPLOYEES TO PCB-CONTAMINATED DUST, SOIL OR SEDIMENT; AND MINIMIZE THE AMOUNT OF PCB-CONTAMINATED SOIL MIGRATING FROM THE PROPERTY IN SURFACE WATER RUNOFF. EPA INSTALLED BARRIERS ACROSS DRAINAGEWAYS DURING 1989 TO MORE EFFECTIVELY INTERCEPT PCB-CONTAMINATED RUNOFF. ALSO AS MENTIONED ABOVE, EPA ENTERED INTO AN ADMINISTRATIVE ORDER ON CONSENT WITH THE MEWSC, WHEREBY THE GROUP AGREED TO PERFORM THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS).

2.4 NATIONAL PRIORITIES LIST STATUS

THE MISSOURI ELECTRIC WORKS SITE WAS PROPOSED FOR LISTING ON THE NATIONAL PRIORITIES LIST (NPL) IN JUNE 1989. THE MEW SITE WAS LISTED ON THE NPL ON FEBRUARY 21, 1990.

#CP

3.0 COMMUNITY PARTICIPATION

EPA AND THE MISSOURI DEPARTMENT OF HEALTH HELD MEETINGS WITH ADJACENT PROPERTY OWNERS AND OTHER INTERESTED CITIZENS IN CAPE GIRARDEAU, MISSOURI ON JULY 11 AND 12, 1989. THE PURPOSE OF THESE MEETINGS WAS TO DISCUSS THE SITE CONDITIONS AND THE HEALTH RISKS THAT THE SITE REPRESENTED TO THE GENERAL PUBLIC. EPA STAFF PARTICIPATED IN TWO LOCAL CAPE GIRARDEAU, MISSOURI RADIO TALK SHOWS DURING JULY 1989; INTERESTED CITIZENS WERE ABLE TO "CALL-IN" AND ASK QUESTIONS OF THE EPA STAFF CONCERNING THE MISSOURI ELECTRIC WORKS SITE AND THE RELATED ACTIVITIES.

THE ADMINISTRATIVE RECORD WAS PLACED IN THE CAPE GIRARDEAU PUBLIC LIBRARY ON AUGUST 11, 1989. A PUBLIC MEETING WAS HELD IN CAPE GIRARDEAU ON SEPTEMBER 19, 1989 TO INFORM THE PUBLIC OF THE DETAILS OF THE ONGOING REMEDIAL INVESTIGATION AND TO IDENTIFY POSSIBLE REMEDIAL ALTERNATIVES THAT WOULD BE CONSIDERED DURING THE FEASIBILITY STUDY. A SECOND PUBLIC MEETING WAS HELD ON JUNE 11, 1990 TO INFORM THE PUBLIC OF THE REMEDIAL INVESTIGATION FINDINGS AND TO AGAIN IDENTIFY THE REMEDIAL ALTERNATIVES THAT WOULD BE CONSIDERED DURING THE FEASIBILITY STUDY. FACT SHEETS, IDENTIFYING SIGNIFICANT SITE ACTIVITIES, WERE MAILED TO EVERYONE ON THE SITE MAILING LIST (WHICH INCLUDED LOCAL MEDIA, OFFICIALS AND PRPS) DURING JUNE, AUGUST, AND

NOVEMBER 1989 AND MARCH, MAY AND JULY 1990.

THE RI/FS REPORTS AND PROPOSED PLAN FOR THE MISSOURI ELECTRIC WORKS SITE WERE RELEASED TO THE PUBLIC ON AUGUST 18, 1990. THESE THREE DOCUMENTS WERE INCLUDED IN THE ADDENDUM TO THE ADMINISTRATIVE RECORD LOCATED IN THE EPA RECORD CENTER, REGION VII AND AT THE CAPE GIRARDEAU, MISSOURI PUBLIC LIBRARY. NOTICE OF THE AVAILABILITY OF THESE DOCUMENTS WAS PUBLISHED IN THE NEWS GUARDIAN AND THE SOUTHEAST MISSOURIAN ON AUGUST 19, 1990. A PUBLIC COMMENT PERIOD WAS HELD FROM AUGUST 19 TO SEPTEMBER 17, 1990. IN ADDITION, A PUBLIC HEARING WAS HELD ON AUGUST 30, 1990. AT THIS MEETING, REPRESENTATIVES FROM THE EPA, THE MISSOURI DEPARTMENT OF NATURAL RESOURCES (MDNR), THE MISSOURI DEPARTMENT OF HEALTH (MDOH) AND THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY (ATSDR) WERE AVAILABLE TO ANSWER QUESTIONS ABOUT PROBLEMS AT THE SITE AND THE REMEDIAL ALTERNATIVES UNDER CONSIDERATION. EPA'S RESPONSE TO THE COMMENTS RECEIVED DURING THIS COMMENT PERIOD IS EMBODIED IN THE RESPONSIVENESS SUMMARY.

#SRRA

4.0 SCOPE AND ROLE OF RESPONSE ACTION

THE REMEDIAL ACTION TO BE PERFORMED AT THE MISSOURI ELECTRIC WORKS SITE, HAS BEEN DIVIDED INTO TWO PARTS: THE FIRST PART ADDRESSES THE CONTAMINATED SOILS. THE SECOND PART ADDRESSES THE CONTAMINATED GROUND WATER. THE CONTAMINATED SOILS POSE A THREAT, CURRENT OR POTENTIAL, TO HUMAN HEALTH AND THE ENVIRONMENT DUE TO THE RISKS OF POSSIBLE INGESTION, INHALATION OR DERMAL CONTACT WITH THE SOILS. THE CONTAMINATED GROUND WATER POSES A THREAT, CURRENT OR POTENTIAL, TO HUMAN HEALTH AND THE ENVIRONMENT BECAUSE OF POSSIBLE FUTURE INGESTION OF DRINKING WATER FROM WELLS THAT CONTAIN CONTAMINANTS ABOVE HEALTH-BASED LEVELS. THE PURPOSE OF THE RESPONSE ACTIONS IS TO PREVENT AND/OR MINIMIZE CURRENT OR FUTURE EXPOSURE TO THE CONTAMINATED SOILS AND GROUND WATER. THESE ACTIONS ARE EXPECTED TO BE THE FINAL RESPONSE ACTIONS FOR THE MEW SITE.

#SCS

5.0 SITE CHARACTERISTICS SUMMARY

NINE CONTAMINANTS OF CONCERN WERE DETECTED AT THE SITE DURING THE INVESTIGATIONS. THESE CONTAMINANTS INCLUDE POLYCHLORINATED BIPHENYLS (PCBS) AND VOLATILE ORGANIC COMPOUNDS (VOCS); SPECIFICALLY, METHYLENE CHLORIDE, TRICHLOROETHANE, TRANS-1,2-DICHLOROETHENE, CHLOROBENZENE, 1,1-DICHLOROETHANE, TRICHLOROETHENE, TETRACHLOROETHENE, AND BENZENE. THE PRESENCE OF THESE CONTAMINANTS IS THE RESULT OF PAST HANDLING, DISPOSAL, AND STORAGE PRACTICES AT THE SITE.

APPROXIMATELY 75 PERCENT OF THE SURFACE SOILS ON THE MISSOURI ELECTRIC WORKS PROPERTY WERE FOUND TO BE CONTAMINATED WITH PCBS AT CONCENTRATIONS OF 10 PPM OR GREATER (SEE FIGURE 5). PCBS ADSORBED ONTO THE SOILS HAVE MIGRATED, PRIMARILY VIA STORM WATER RUNOFF, ONTO SURROUNDING PROPERTIES. THIS CONTAMINATION IS GENERALLY LOCATED ALONG DRAINAGE PATHWAYS WITH THE CONCENTRATIONS DECREASING WITH GREATER DISTANCE FROM MEW. THE HIGHEST CONCENTRATION OF PCBS OBSERVED IN ANY OFFSITE SAMPLE (2,030 PPM) WAS FOUND IN A DRAINAGE CHANNEL AT THE BOUNDARY BETWEEN THE MEW PROPERTY AND THE MORRILL PROPERTY LOCATED TO THE SOUTH.

#SSR

6.0 SUMMARY OF SITE RISKS

A BASELINE RISK ASSESSMENT OF THE MEW SITE WAS PERFORMED BY THE MEWSC TO ASSESS THE RISKS POSED TO HUMAN HEALTH BY THE PCB AND VOC-CONTAMINATED SOILS AND SEDIMENTS AND THE VOC CONTAMINATED GROUND WATER. THE COMPOUNDS OF CONCERN AND THE MEDIA IN WHICH THEY WERE DETECTED ARE PRESENTED IN TABULAR FORM BELOW.

DETECTED COMPOUNDS	ENVIRONMENTAL MEDIA
PCBS	SOIL, SEDIMENT, AIR
METHYLENE CHLORIDE	SOIL
TRICHLOROETHANE	SOIL
TRANS 1,2-DICHLOROETHENE	GROUND WATER
CHLOROBENZENE	SOIL, GROUND WATER
1,1 DICHLOROETHANE	GROUND WATER
TRICHLOROETHENE	GROUND WATER
TETRACHLOROETHENE	GROUND WATER
BENZENE	GROUND WATER

PATHWAYS THROUGH WHICH POPULATIONS COULD POTENTIALLY BECOME EXPOSED WERE EVALUATED. THESE PATHWAYS INCLUDE: 1) INGESTION OF CONTAMINATED SOILS; 2) DERMAL (SKIN) CONTACT WITH CONTAMINATED SOILS; 3) INHALATION OF CONTAMINATED SOIL PARTICLES AND VAPORS; AND 4) INGESTION OF CONTAMINATED GROUND WATER.

INCREMENTAL LIFETIME CANCER RISKS AND A MEASURE OF THE POTENTIAL FOR NONCARCINOGENIC ADVERSE HEALTH EFFECTS WERE ESTIMATED FOR EACH POPULATION IN EACH EXPOSURE SCENARIO. FOR CARCINOGENIC COMPOUNDS, RISKS WERE ESTIMATED BY MULTIPLYING THE ESTIMATED EXPOSURE DOSE BY THE CANCER POTENCY FACTOR OF EACH CONTAMINANT. THE PRODUCT OF THESE TWO VALUES IS AN ESTIMATE OF THE INCREMENTAL CANCER RISK.

FOR NONCARCINOGENIC COMPOUNDS, A HAZARD INDEX (HI) VALUE WAS ESTIMATED. THIS VALUE IS A RATIO BETWEEN THE ESTIMATED EXPOSURE DOSE AND THE REFERENCE DOSE (RFD) WHICH REPRESENTS THE AMOUNT OF TOXICANT THAT IS UNLIKELY TO CAUSE ADVERSE HEALTH EFFECTS. GENERALLY, IF THE HI IS LESS THAN ONE, THE PREDICTED EXPOSURE DOSE IS NOT EXPECTED TO CAUSE HARMFUL NONCARCINOGENIC HUMAN HEALTH EFFECTS. WHERE THE HI EXCEEDS ONE, THE POTENTIAL TO CAUSE ADVERSE NONCARCINOGENIC HUMAN HEALTH EFFECTS INCREASES AS THE HI INCREASES.

DUE TO THE POTENTIAL ADDITIVE EFFECTS OF INGESTION, INHALATION AND DERMAL CONTACT TO CONTAMINANTS VIA DIFFERENT PATHWAYS, EXPOSURE ROUTES FOR SOIL WERE IDENTIFIED. THERE ARE THREE ROUTES AT WHICH POPULATIONS COULD POTENTIALLY BE EXPOSED VIA ONE OR A COMBINATION OF SCENARIOS. THESE EXPOSURE ROUTES ARE: 1) OCCUPATIONAL (SITE WORKERS); 2) RECREATIONAL USERS OF THE SITE, BOTH ADULTS AND CHILDREN; AND 3) RESIDENTIAL POPULATIONS, BOTH ADULTS AND CHILDREN. THESE EXPOSURE SCENARIOS WERE EVALUATED FOR CURRENT AND FUTURE USES OF THE SITE. THE FUTURE USE SCENARIO INCLUDED INGESTION OF CONTAMINATED GROUND WATER AS AN ADDITIONAL EXPOSURE PATHWAY.

FOR PURPOSES OF THE RISK ASSESSMENT, IT WAS ASSUMED THAT NO REMEDIAL ACTION WOULD BE PERFORMED AT THE SITE IN ORDER TO EVALUATE THE POSSIBLE FUTURE RISKS POSED BY THE CONTAMINATION. THE RISKS POSED BY THE SOIL CONTAMINATION AT THE SITE ARE SUMMARIZED IN TABLES 1 TO 6.

NO CURRENT EXPOSURE RISK WAS EVALUATED FOR GROUND WATER. INFORMATION INDICATES THAT THERE ARE CURRENTLY NO USERS OF THE UPPER PORTION OF THE GROUND WATER. NO CONTAMINATION WAS DETECTED IN THE GROUND WATER SAMPLES OBTAINED FROM THE ONSITE DRINKING WATER WELL. RISKS TO HUMAN HEALTH WERE EVALUATED ASSUMING THAT DRINKING WATER WELLS WOULD BE INSTALLED IN THE CONTAMINATED ZONE OF THE BEDROCK AQUIFER IN THE FUTURE, FOR HUMAN CONSUMPTION. TABLES 7 TO 9 SUMMARIZE THE RISKS ASSOCIATED WITH INGESTION OF CONTAMINATED GROUND WATER.

THE ANALYSES PERFORMED INDICATED THAT THE MEW SITE CURRENTLY PRESENTS AN UNACCEPTABLE RISK TO HUMAN HEALTH AND THE ENVIRONMENT FOR ALL OF THE EXPOSURE SCENARIOS. WITH RESPECT TO THE GROUND WATER, AVAILABLE INFORMATION ON THE REGIONAL GEOLOGIC CONDITIONS INDICATES THERE IS NOT A BARRIER IN THE LIMESTONE BEDROCK TO PREVENT DOWNWARD CONTAMINANT MIGRATION IN THE GROUND WATER. THE DEPTH TO THE FIRST BARRIER IS ESTIMATED TO BE APPROXIMATELY 1,000 FEET. BECAUSE THE POTENTIAL FOR EXPOSURE IS GREATER DUE TO INCREASED GROUND WATER USAGE AT SUCH DEPTHS, THE CONTAMINATION MUST BE ADDRESSED.

#RG

7.0 REMEDIAL GOALS

EPA'S NATIONAL GOAL FOR THE SUPERFUND PROGRAM IS TO SELECT REMEDIES THAT WILL BE PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT, THAT WILL MAINTAIN PROTECTION OVER TIME AND THAT WILL MINIMIZE UNTREATED WASTE. IN ESTABLISHING REMEDIAL GOALS FOR THE MEW SITE, EPA CONSIDERED APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) SPECIFIC TO THE CONTAMINANTS OF CONCERN; THE RISK ASSESSMENT; MAXIMUM CONTAMINANT LEVELS (MCLS) AND MAXIMUM CONTAMINANT LEVEL GOALS (MCLGS) ESTABLISHED UNDER THE SAFE DRINKING WATER ACT; AND EPA GUIDANCE AND POLICY, SPECIFICALLY THE TSCA PCB SPILL CLEANUP POLICY, 40 CFR PART 761 (A COMPLETE LIST OF ARARS FOR THE SELECTED REMEDY IS INCLUDED AS APPENDIX A).

FOR SOIL CONTAMINATION, EPA CONSIDERS A CLEANUP LEVEL OF 10 PPM PCBS TO A DEPTH OF FOUR FEET AND 100 PPM IN SOILS BELOW FOUR FEET TO BE PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT. WITH THESE CLEANUP LEVELS, THE GEOMETRIC MEAN OF ANALYTICAL DATA OF SAMPLES OBTAINED OUTSIDE THE AREA TO BE EXCAVATED IS ESTIMATED TO BE 6 PPM. THIS RESIDUAL CONTAMINATION CONCENTRATION, AFTER CLEANUP, REPRESENTS AN EXCESS UPPER BOUND LIFETIME CANCER RISK ON THE ORDER OF 2 X (10-5). THESE CLEANUP LEVELS ARE CONSISTENT WITH THE TSCA PCB SPILL CLEANUP POLICY.

FOR GROUND WATER CONTAMINATION, EPA HAS DETERMINED THAT A CLEANUP LEVEL OF 20 PPB FOR CHLOROBENZENE, WHICH HAS BEEN DETECTED AT LEVELS UP TO 240 PPB, AND 5 PPB FOR TRICHLOROETHENE (TCE), WHICH HAS BEEN DETECTED AT LEVELS UP TO 19 PPB, IS ADEQUATE TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT. THE RESIDUAL CONTAMINATION LEVELS, AFTER CLEANUP, REPRESENT AN EXCESS UPPER BOUND LIFE-TIME CANCER RISK ON THE ORDER OF 1 X (10-5). THESE CLEANUP LEVELS COMPLY WITH MISSOURI WATER QUALITY STANDARDS AND THE MCLS FOR THOSE CONTAMINANTS.

THE CLEANUP LEVELS FOR THE MEW SITE RESULT IN CANCER RISKS IN EXCESS OF 1 X (10-6), WHICH IS THE POINT OF DEPARTURE FOR DETERMINING REMEDIATION GOALS. THE CLEANUP LEVELS FOR THE SITE HAVE BEEN IDENTIFIED AFTER CONSIDERING THE BACKGROUND LEVELS OF PCBS IN THE ENVIRONMENT AND THE TECHNICAL IMPRACTICABILITY OF REMOVING PCBS BELOW 10 PPM. GROUND WATER CLEANUP LEVELS WERE SELECTED BASED ON THE TECHNICAL LIMITS OF REMEDIATION. CASE STUDIES FOR GROUND WATER REMEDIATIONS HAVE INDICATED THAT THE EFFECTIVE REMOVAL OF CONTAMINANTS FROM THE GROUND WATER LESSENS AS CONTAMINANT CONCENTRATIONS DECREASE.

#DA

8.0 DESCRIPTION OF ALTERNATIVES

THE MEWSC PERFORMED A FEASIBILITY STUDY (FS) TO DEVELOP AND EVALUATE ALTERNATIVES FOR REMEDIATION OF THE CONTAMINATED SOIL AND GROUND WATER AT THE SITE. THE REMEDIAL ALTERNATIVES DEVELOPED AND EVALUATED IN THE FS ARE PRESENTED BELOW. (ALTERNATIVES FOR CONTAMINATED SOIL ARE IDENTIFIED WITH AN "SM" PREFIX; GROUND WATER ALTERNATIVES ARE IDENTIFIED WITH A "GM" PREFIX. IDENTIFICATION NUMBERS MATCH THOSE PRESENTED IN THE FS.)

FOR CONTAMINATED SOILS:

- ALTERNATIVE SM-1 - 4 NO ACTION ALTERNATIVE
- ALTERNATIVE SM-2 - 4 LIMITED ACTION ALTERNATIVE
- ALTERNATIVE SM-4 - 4 ASPHALT CAP
- ALTERNATIVE SM-6 - 4 OFFSITE LANDFILL
- ALTERNATIVE SM-7 - 4 SOLIDIFICATION/FIXATION
- ALTERNATIVE SM-8 - 4 SOLVENT EXTRACTION
- ALTERNATIVE SM-10 - IN-SITU VITRIFICATION

- ALTERNATIVE SM-11 - ROTARY KILN INCINERATION

FOR GROUND WATER CONTAMINATION:

- ALTERNATIVE GM-1 - 4 NO ACTION
- ALTERNATIVE GM-2 - 4 LIMITED ACTION ALTERNATIVE
- ALTERNATIVE GM-3 - 4 EXTRACTION WITH DISCHARGE TO SURFACE WATER
- ALTERNATIVE GM-4 - 4 EXTRACTION WITH DISCHARGE TO POTW
- ALTERNATIVE GM-5 - 4 AIR-STRIPPING
- ALTERNATIVE GM-6 - 4 LIQUID PHASE CARBON ADSORPTION
- ALTERNATIVE GM-7 - 4 ULTRAVIOLET CATALYZED OXIDATION

8.1 SOIL/SEDIMENT REMEDIAL ALTERNATIVES

ALL PCB-CONTAMINATED SOILS WITH CONCENTRATIONS IN EXCESS OF 10 PPM WILL BE ADDRESSED DURING THIS REMEDIAL ACTION. THE VOLUME OF PCB-CONTAMINATED SOILS AND SEDIMENTS TO BE ADDRESSED WITH THIS REMEDIAL ACTION IS ESTIMATED TO BE 20,500 CUBIC YARDS. THIS ESTIMATE IS BASED ON THE RI AND OTHER INVESTIGATIONS PERFORMED AT THE SITE.

8.1.1 NO ACTION ALTERNATIVE (SM-1)

AS SET FORTH IN THE NATIONAL CONTINGENCY PLAN, 40 CFR PART 300 (NCP), A NO ACTION ALTERNATIVE MUST BE CONSIDERED IN THE EVALUATION AND SELECTION OF A REMEDIAL ACTION FOR NPL SITES. THIS ALTERNATIVE WOULD PROVIDE NO TREATMENT OF THE SOILS OR GROUND WATER, NOR ANY ENGINEERING CONTROLS OR INSTITUTIONAL CONTROLS. CURRENT SITE CONDITIONS, MIGRATION ROUTES, AND EXPOSURES WOULD REMAIN UNCHANGED IN THE NEAR- AND LONG-TERM. TREATABILITY TESTS WILL NOT BE REQUIRED. NO COSTS WOULD BE ASSOCIATED WITH THIS REMEDY.

8.1.2 LIMITED ACTION ALTERNATIVE (SM-2)

THE LIMITED ACTION ALTERNATIVE FOR THE MEW SITE INCORPORATES PHYSICAL AND INSTITUTIONAL CONTROLS TO LIMIT DIRECT EXPOSURE TO THE CONTAMINATED SOILS/SEDIMENTS/WASTE, AND PROVIDES FOR LONG-TERM MONITORING AND MAINTENANCE OF THE SITE. THIS ALTERNATIVE WOULD CONSIST OF: INSTALLATION OF A PHYSICAL BARRIER AROUND ALL ONSITE AND OFFSITE AREAS EXHIBITING SURFICIAL SOIL PCB CONCENTRATIONS OF 10 PPM OR GREATER; USE OF INSTITUTIONAL CONTROLS TO PROHIBIT DISTURBANCE OF CONTAMINATED SOILS/SEDIMENTS/WASTE AND TO RESTRICT USE OF THE SITE TO INDUSTRIAL PURPOSES; AND MAINTENANCE OF THE SITE INCLUDING VEGETATIVE COVER, PERIMETER FENCING, AND ALL OTHER APPROPRIATE SUPPORT FACILITIES. TREATABILITY TESTS WOULD NOT BE REQUIRED. MONITORING AND MAINTENANCE WOULD CONTINUE FOR AT LEAST 30 YEARS.

ESTIMATED TIME FOR CONSTRUCTION	2 MONTHS
ESTIMATED TIME TO IMPLEMENT	30 YEARS
ESTIMATED CAPITAL COST	$65,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$7,000
ESTIMATED PRESENT WORTH COST	$140,325

8.1.3 ASPHALT CAP ALTERNATIVE (SM-4)

THE ALTERNATIVE WOULD INVOLVE CONSOLIDATING THE CONTAMINATED SOILS AND COVERING THEM WITH A LOW PERMEABILITY ASPHALT CAP. THE PURPOSE OF THIS CAP WOULD BE TO REDUCE THE POTENTIAL FOR MIGRATION OF CONTAMINATION INTO THE GROUND WATER, PREVENT DIRECT CONTACT WITH THE WASTE MASS AND REDUCE POTENTIAL MIGRATION FROM STORM WATER AND/OR PRECIPITATION RUNOFF. ALL CONTAMINATED SOILS FROM OFFSITE AREAS WOULD BE CONSOLIDATED WITH SOILS FROM SOME ONSITE AREAS TO OCCUPY APPROXIMATELY FOUR ACRES LOCATED IN THE EASTERN TWO-THIRDS OF THE MEW PROPERTY. RIP-RAP

WOULD BE PLACED ON THE SIDE SLOPES OF THE PROPERTY TO MINIMIZE THE POTENTIAL FOR MIGRATION DUE TO EROSION. HEAVY EQUIPMENT WOULD BE USED TO CONSTRUCT THE CAP, WHICH WOULD PROBABLY BE CONSTRUCTED OF ASPHALT. TREATABILITY TESTS WOULD NOT BE REQUIRED. AFTER CONSTRUCTION, FENCES WOULD BE ERECTED AROUND THE MEW PROPERTY, SIGNS WOULD BE INSTALLED AND A MONITORING/MAINTENANCE PROGRAM INITIATED. MONITORING AND MAINTENANCE WOULD CONTINUE FOR AT LEAST 30 YEARS.

ESTIMATED TIME FOR CONSTRUCTION	2 MONTHS
ESTIMATED TIME TO IMPLEMENT	20 YEARS
ESTIMATED CAPITAL COST	$825,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$13,000
ESTIMATED PRESENT WORTH COST	$950,000

8.1.4 OFFSITE LANDFILL ALTERNATIVE (SM-6)

ALL SOILS CONTAMINATED WITH CONCENTRATIONS OF PCBS OF 10 PPM OR GREATER WOULD BE EXCAVATED TO A DEPTH OF FOUR FEET; BELOW THAT DEPTH, THOSE AREAS WITH PCB CONCENTRATIONS IN EXCESS OF 100 PPM WOULD BE EXCAVATED. THE EXCAVATED MATERIAL WOULD BE TRANSPORTED OFFSITE BY TRUCK TO A TSCA-PERMITTED CHEMICAL WASTE LANDFILL. THE EXCAVATED AREAS WOULD BE BACKFILLED, USING CLEAN MATERIAL FROM OFFSITE BORROW AREAS, AND REVEGETATED. THE PRINCIPAL COMPONENTS OF THIS ALTERNATIVE WOULD CONSIST OF IDENTIFICATION OF AN EPA-APPROVED FACILITY TO ACCEPT THE PCB-CONTAMINATED SOILS; EXCAVATION AND TRANSPORTATION OF THE CONTAMINATED SOILS; PLACEMENT OF THE CONTAMINATED SOILS IN THE SELECTED FACILITY; RESTORATION OF THE MEW SITE, INCLUDING BACKFILLING, COMPACTION, AND FINAL GRADING FOR DRAINAGE; AND REVEGETATION OF THE MEW SITE. TESTING OF THE EXCAVATED SOILS WOULD BE REQUIRED TO VERIFY LANDFILL ACCEPTANCE.

ESTIMATED TIME TO IMPLEMENT	2 MONTHS
ESTIMATED CAPITAL COST	$10,900,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$0
ESTIMATED PRESENT WORTH COST	$10,900,000

NOTE: FOR SOIL ALTERNATIVES SM-6, SM-7, SM-8, AND SM-10, ALL SOILS CONTAMINATED WITH PCB CONCENTRATIONS OF 10 PPM OR GREATER WOULD BE EXCAVATED TO A DEPTH OF FOUR FEET; BELOW THAT DEPTH SOILS CONTAINING PCBS IN EXCESS OF 100 PPM WOULD BE EXCAVATED. THE EXCAVATED MATERIAL WOULD BE STOCKPILED ON THE MEW PROPERTY IN AREAS CONSTRUCTED TO CONTAIN RUNOFF AND THE PILES WOULD BE COVERED TO MINIMIZE CONTAMINANT MIGRATION DUE TO WIND EROSION.

8.1.5 ONSITE STABILIZATION/FIXATION ALTERNATIVE (SM-7)

STABILIZATION/FIXATION IS A TREATMENT PROCESS WHICH EMPLOYS ADDITIVES TO DIMINISH THE HAZARDOUS NATURE OF MATERIALS CONTAINING HAZARDOUS CONSTITUENTS BY CONVERTING THE WASTE INTO A FORM THAT IMMOBILIZES THE HAZARDOUS CONSTITUENTS WITHIN A STABLE MATRIX. STABILIZATION PROCESSES TYPICALLY INVOLVE MIXING THE WASTE WITH CHEMICAL REAGENTS TO IMMOBILIZE CONTAMINANTS AND IMPROVE THE PHYSICAL PROPERTIES OF THE WASTE. THIS PROCESS WOULD REDUCE THE MIGRATION POTENTIAL OF THE PCBS. TREATABILITY TESTS WOULD BE REQUIRED TO IDENTIFY THE MOST EFFECTIVE ADDITIVES AND THE OPTIMUM PERCENTAGE AND RATIOS OF THE ADDITIVES. THE EXCAVATED SOILS WOULD BE PROCESSED AND FED INTO A MIXER (SIMILAR TO A PUG MILL) WHERE THE MOISTURE CONTENT WOULD BE ADJUSTED AND A STABILIZATION/FIXATION AGENT ADDED. TIGHT CONTROLS ON MIXTURE RATIOS WOULD BE EXERCISED. A HIGH DEGREE OF QUALITY CONTROL WOULD BE REQUIRED AND EXERCISED DURING THE MIXING AND BLENDING PROCESS. AN AREA ON THE MEW PROPERTY WOULD BE EXCAVATED TO CREATE CELLS WITH SUFFICIENT VOLUME TO RECEIVE THE PROCESSED SOILS. THE PROCESSED SOILS WOULD BE TRANSPORTED TO THE EXCAVATED MONOLITH AREA, PLACED AND COMPACTED IN THE CELLS. A SOIL COVER, THIRTY (30) INCHES THICK WOULD BE CONSTRUCTED OVER THE CELLS. THE COHESIVE NATURE (CLAYEY) OF THE SITE SOILS COULD CAUSE A PROBLEM IF ADDITIVES ARE NOT EFFECTIVE IN SOLIDIFYING THEM OR FIXING THE CONTAMINATION; TREATABILITY TESTS WOULD BE REQUIRED. INSTITUTIONAL CONTROLS WOULD BE REQUIRED TO RESTRICT USE OF THE MEW PROPERTY. THE AREA WOULD BE FENCED AND SIGNS INSTALLED. LONG- TERM MONITORING WOULD BE INITIATED.

ESTIMATED TIME FOR CONSTRUCTION	1 YEAR
ESTIMATED TIME TO IMPLEMENT	30 YEARS
ESTIMATED CAPITAL COST	$4,300,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$13,500
ESTIMATED PRESENT WORTH COST	$4,400,000

8.1.6 SOLVENT EXTRACTION ALTERNATIVE (SM-8)

THIS ALTERNATIVE WOULD EMPLOY A CHEMICAL SEPARATION PROCESS UTILIZING ONE OR MORE OF A FAMILY OF ALIPHATIC AMINE OR OTHER SOLVENTS. WHILE THE PROCESSES ARE DESIGNED TO RECOVER AND RECYCLE SOLVENTS USED FOR EXTRACTION, THE FINE-GRAINED NATURE OF THE SOILS AT THE MEW SITE MAY HINDER RECOVERY, RESULTING IN SOME AMOUNT OF SOLVENT REMAINING IN TREATED SOILS. SITE SOILS MAY REDUCE THE EFFECTIVENESS OF THE PROCESS THEREBY MAKING IT MORE DIFFICULT TO IMPLEMENT. THE AVAILABILITY OF THE PROCESS EQUIPMENT IS UNCERTAIN. SOLVENT EXTRACTION PROCESSES APPLIED TO SOIL CONTAMINATION ARE GENERALLY CONSIDERED TO BE IN A DEVELOPMENTAL/ DEMONSTRATION STATE. STUDIES HAVE SHOWN THE PROCESS TO BE CAPABLE OF 99+ PERCENT REMOVAL OF PCBS FROM A WIDE VARIETY OF SLUDGES, SOILS AND SEDIMENTS. EXCAVATED SOILS WOULD REQUIRE PROCESSING PRIOR TO TREATMENT. THE SOILS WOULD BE PLACED IN A CLOSED MIXING CHAMBER WHERE A CHILLED SOLVENT WOULD THEN BE INTRODUCED. MIXING WOULD OCCUR, THE SOLIDS WOULD BE ALLOWED TO SETTLE, AND THE SOLVENT WOULD BE PUMPED OFF. ADDITIONAL SOLVENT "CHARGES" WOULD BE ADDED, AS NECESSARY, TO ATTAIN CLEANUP STANDARDS (SEE FIGURE 6 FOR A DIAGRAM OF THE PROCESS). EXTRACTED PCBS WOULD BE COLLECTED, STORED AND DISPOSED OFFSITE BY INCINERATION IN ACCORDANCE WITH TSCA REGULATIONS. RESIDUAL WATER MAY BE A BYPRODUCT OF THE PROCESS. THIS WATER COULD REQUIRE TESTING AND ADDITIONAL TREATMENT. CONSTRUCTION OF A WASTEWATER TREATMENT PLANT TO PROCESS THE RESIDUAL WATER COULD BE NECESSARY. (THE COSTS PRESENTED BELOW DO NOT INCLUDE THOSE FOR A WASTEWATER TREATMENT PLANT.) THE EXCAVATED AREAS WOULD BE BACKFILLED, USING THE TREATED SOILS AND COVERED WITH A CLEAN SOIL COVER.

A TREATABILITY STUDY WOULD BE NEEDED FOR THIS REMEDIAL ACTION ALTERNATIVE TO EVALUATE ITS FEASIBILITY FOR THE SITE CONDITIONS AND TO EVALUATE THE REACTION TIME NEEDED TO ACHIEVE CLEANUP LEVELS.

ESTIMATED TIME TO IMPLEMENT	1 YEAR
ESTIMATED CAPITAL COST	$6,400,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$0
ESTIMATED PRESENT WORTH COST	$6,400,000

8.1.7 IN-SITU VITRIFICATION ALTERNATIVE (SM-10)

IN-SITU VITRIFICATION IS A TREATMENT PROCESS THAT USES AN ELECTRIC CURRENT TO HEAT SOILS TO THEIR MELTING POINT. DUE TO THE RELATIVELY SHALLOW DEPTH OF CONTAMINATION AT THE SITE, CONTAMINATED SOILS WOULD BE EXCAVATED AND PLACED IN 12 TO 15-FOOT TRENCHES FOR TREATMENT. ELECTRODES WOULD BE PLACED INTO THE SOIL IN THE TRENCHES AND AN ELECTRIC CURRENT INDUCED BETWEEN THE ELECTRODES. THE CURRENT WOULD HEAT THE SOILS, CAUSING THEM TO MELT. THE MELTING SOILS WOULD CAUSE A 20 TO 40 PERCENT REDUCTION IN THE VOLUME OF THE SOILS BEING TREATED. THIS PROCESS HAS BEEN SHOWN TO DESTROY ORGANIC CONTAMINANTS, I.E, PCBS, BY PYROLYZING THEM (SEE FIGURE 7). BY-PRODUCTS OF THE PYROLYSIS MIGRATE TO THE SURFACE AND BURN IN THE PRESENCE OF OXYGEN. A SPECIALLY DESIGNED HOOD WOULD BE PLACED OVER THE TREATMENT AREA TO COLLECT GASES GENERATED DURING THE PROCESSING AND MAINTAIN A CONTROLLED ATMOSPHERE IN WHICH THE GASES COULD BURN. THE GASES IN THE HOOD WOULD BE PROCESSED THROUGH VARIOUS STEPS BEFORE BEING RELEASED INTO THE ATMOSPHERE. TREATABILITY TESTS ARE LIKELY TO BE NEEDED.

ESTIMATED TIME TO IMPLEMENT	1 YEAR
ESTIMATED CAPITAL COST	$11,200,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$0
ESTIMATED PRESENT WORTH COST	$11,200,000

8.1.8 ONSITE INCINERATION ALTERNATIVE (SM-11)

THE ONSITE INCINERATION ALTERNATIVE PROVIDES AN ONSITE TREATMENT PROCESS TO MANAGE PCB-CONTAMINATED SOILS FROM ALL ONSITE AND OFFSITE AREAS. ROTARY KILN INCINERATORS (SEE FIGURE 8) ARE PROBABLY THE MOST COMMON TYPE OF EQUIPMENT USED FOR MOBILE INCINERATION BECAUSE THEY HAVE BEEN COMMERCIALLY PROVEN, PROVIDE FLEXIBILITY IN HANDLING MANY TYPES OF MATERIALS AND PROVIDE GOOD MIXING AND LONG RESIDENCE TIMES FOR SOLIDS. A TRIAL BURN WOULD BE REQUIRED TO IDENTIFY THE RESIDENCE TIME REQUIRED TO DESTROY THE PCB CONTAMINATION.

THE INCINERATION OPERATION WOULD REQUIRE APPROXIMATELY ONE ACRE OF SPACE AT THE SITE. THE CONTAMINATED SOILS WOULD BE PROCESSED TO OBTAIN THE PROPER PARTICLE SIZE AND THEN "FED" INTO THE LOWER END OF THE COMBUSTION CHAMBER. USE OF A HIGH COMBUSTION AIR VELOCITY AND CIRCULATING SOLIDS WOULD RESULT IN A UNIFORM TEMPERATURE AROUND THE COMBUSTION LOOP RESULTING IN RAPID HEATING OF THE MATERIALS AND HIGHLY EFFICIENT COMBUSTION, THUS ELIMINATING THE NEED FOR AN AFTERBURNER OR SECONDARY COMBUSTION OF OFF-GASES. THERMAL TREATMENT WOULD ACHIEVE A PCB-DESTRUCTION EFFICIENCY OF 99.9999 PERCENT.

EXHAUST GASES WOULD BE ROUTED TO AIR POLLUTION CONTROL DEVICES CONSISTING OF FLUE-GAS COOLERS AND PARTICULATE REMOVAL SYSTEMS BEFORE BEING RELEASED TO THE ATMOSPHERE. ACID GASES WOULD BE REMOVED IN-SITU. DURING OPERATION, TREATED SOIL AND ASH WOULD BE REMOVED PERIODICALLY AND COOLED.

AFTER THERMAL TREATMENT, THE TREATED SOILS AND ASH WOULD BE TESTED USING, THE TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP) PRIOR TO THEIR USE AS BACKFILL FOR THE EXCAVATED AREAS OF THE SITE. AFTER BACKFILLING THE EXCAVATED AREAS, A SOIL COVER WOULD BE CONSTRUCTED OVER THE SITE AND THE SITE WOULD BE REVEGETATED.

ESTIMATED TIME TO IMPLEMENT	1-2 YEARS
ESTIMATED CAPITAL COST	$8,400,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$0
ESTIMATED PRESENT WORTH COST	$8,400,000

8.2 GROUND WATER REMEDIAL ALTERNATIVES

BASED ON AVAILABLE DATA, IT IS ESTIMATED THAT THE VOLUME OF GROUND WATER THAT WILL REQUIRE TREATMENT IS 1,000,000 GALLONS. THIS FIGURE IS BASED ON INFORMATION GATHERED DURING THE INSTALLATION AND SAMPLING OF THE MONITORING WELLS.

8.2.1 NO ACTION ALTERNATIVE (GM-1)

AS SET FORTH IN THE NCP, A NO ACTION ALTERNATIVE MUST BE CONSIDERED IN THE EVALUATION AND SELECTION OF A REMEDIAL ACTION FOR AN NPL SITE. THIS ALTERNATIVE WOULD PROVIDE NO TREATMENT OF GROUND WATER, NO ENGINEERING CONTROLS OR INSTITUTIONAL CONTROLS. CURRENT SITE CONDITIONS, MIGRATION ROUTES AND EXPOSURES WOULD REMAIN UNCHANGED IN THE NEAR- AND LONG-TERM. NO COSTS WOULD BE ASSOCIATED WITH THIS REMEDY.

8.2.2 LIMITED ACTION ALTERNATIVE (GM-2)

THIS ALTERNATIVE WOULD INCORPORATE PHYSICAL AND INSTITUTIONAL CONTROLS TO PREVENT OR LIMIT DIRECT EXPOSURE TO THE CONTAMINATED SOILS/SEDIMENTS AND GROUND WATER AND WOULD PROVIDE FOR MONITORING OF THE GROUND WATER CONTAMINATION. MONITORING OF THE GROUND WATER WOULD BE ACCOMPLISHED USING AN ARRAY OF ONSITE AND DOWNGRADIENT WELLS DESIGNED TO TRACK THE LEADING EDGE OF THE CONTAMINATION PLUME AND QUANTIFY HORIZONTAL MIGRATION WITHIN THE WATER BEARING UNIT. ANALYTICAL DATA GATHERED DURING THE MONITORING ACTIVITIES WOULD BE EVALUATED TO DETERMINE IF ADDITIONAL REMEDIAL ACTIONS ARE NECESSARY. THE MONITORING WOULD BE CONTINUED UNTIL CONTAMINANT LEVELS IN THE GROUND WATER FALL BELOW THE MCLS (IT IS ASSUMED THAT THE MONITORING WOULD CONTINUE FOR 30 YEARS).

ESTIMATED TIME FOR CONSTRUCTION	2 MONTHS
ESTIMATED TIME TO IMPLEMENT	30 YEARS
ESTIMATED CAPITAL COST	$73,500
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$36,000
ESTIMATED PRESENT WORTH COST (30 YEARS, 10 PERCENT)	$375,000

FOR ALTERNATIVES GM-3 THROUGH GM-7, A GROUND WATER EXTRACTION SYSTEM CONSISTING OF SIX TO TEN WELLS WOULD BE CONSTRUCTED. PRIOR TO THE INSTALLATION OF THE GROUND WATER REMEDIATION SYSTEM, ADDITIONAL INVESTIGATION OF THE HYDROGEOLOGIC REGIME IN THE VICINITY OF THE MEW SITE WILL BE PERFORMED. THE PURPOSE OF THIS INVESTIGATION WILL BE TO IDENTIFY INFORMATION NECESSARY FOR THE DESIGN OF THE GROUND WATER REMEDIATION SYSTEM. THIS SYSTEM WOULD BE USED TO REMOVE THE CONTAMINATED GROUND WATER. FIGURE 9 PRESENTS A POSSIBLE CONFIGURATION OF EXTRACTION WELLS AND THEIR RELATION TO THE GROUND WATER CONTAMINANT PLUME.

8.2.3 EXTRACTION AND DISCHARGE TO SURFACE WATERS ALTERNATIVE (GM-3)

AFTER EXTRACTION, THE GROUND WATER WOULD BE DISCHARGED THROUGH AN EFFLUENT MONITORING STATION TO A RELEASE POINT ALONG THE WILSON ROAD DITCH. THIS ALTERNATIVE WOULD ESSENTIALLY REMOVE THE CONTAMINANTS FROM THE GROUND WATER AND PLACE THEM IN THE SURFACE WATER/SEDIMENT AND ATMOSPHERE. IT RELIES SOLELY ON DILUTION TO MEET THE WATER QUALITY CRITERIA. IT WOULD INCREASE THE MOBILITY OF THE CONTAMINANTS DUE TO VOLATILIZATION.

ESTIMATED TIME TO IMPLEMENT	15 YEARS
ESTIMATED CAPITAL COST	$165,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$12,000
ESTIMATED PRESENT WORTH COST (15 YEARS, 10 PERCENT)	$510,000

8.2.4 EXTRACTION WITH DISCHARGE TO PUBLICLY OWNED TREATMENT WORKS(POTW) ALTERNATIVE (GM-4)

AFTER EXTRACTION, THE GROUND WATER WOULD BE DISCHARGED TO THE MUNICIPAL WATER TREATMENT SYSTEM FOR TREATMENT. THIS ALTERNATIVE WOULD CONTINUE UNTIL CLEANUP LEVELS ARE MET (ESTIMATED TO BE 30 YEARS). MONITORING OF THE GROUND WATER QUALITY WOULD BE NEEDED PERIODICALLY TO ENSURE THAT DISCHARGE REQUIREMENTS WERE MET.

ESTIMATED TIME TO IMPLEMENT	30 YEARS
ESTIMATED CAPITAL COST	$100,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST	$108,000
ESTIMATED PRESENT WORTH COST (30 YEARS, 10 PERCENT)	$1,100,000

NOTE: ALL GROUND WATER TREATMENT TECHNOLOGIES DESCRIBED IN THE FOLLOWING PARAGRAPHS ARE ESTIMATED TO CONTINUE FOR A PERIOD OF APPROXIMATELY 15 YEARS. EXTRACTION OF GROUND WATER WOULD CONTROL MIGRATION OF THE CONTAMINANT PLUME. MONITORING TO EVALUATE THE EFFECTIVENESS OF THE TREATMENT TECHNOLOGY AND MAINTENANCE OF THE GROUND WATER EXTRACTION SYSTEM WOULD BE REQUIRED FOR ALL TREATMENT TECHNOLOGIES.

8.2.5 AIR-STRIPPING ALTERNATIVE (GM-5)

AFTER EXTRACTION, THE GROUND WATER WOULD BE PUMPED THROUGH A FILTER SYSTEM TO REMOVE SUSPENDED PARTICULATES. THIS WOULD BE FOLLOWED BY INJECTION INTO THE TOP OF A PACKED AIR-STRIPPER COLUMN EQUIPPED WITH AN AIR BLOWER. THE TREATED WATER EFFLUENT WOULD THEN BE PIPED TO AN OUTFALL ALONG WILSON ROAD OR TO THE LOCAL PUBLICLY OWNED TREATMENT WORKS (POTW). THE VOCS "STRIPPED" FROM THE GROUND WATER WOULD BE PROCESSED THROUGH A VAPOR-PHASE CARBON ADSORPTION FILTER TO PREVENT THE RELEASE OF VOCS TO THE ATMOSPHERE. A SCHEMATIC OF AN AIR-STRIPPING PROCESS IS PRESENTED IN FIGURE 10. THE VOLUME AND QUALITY OF THE TREATED EFFLUENT WOULD BE MONITORED PRIOR TO ITS RELEASE. TREATABILITY STUDIES WOULD BE NEEDED PRIOR TO FINAL DESIGN OF THE SYSTEM. PROCESS RESIDUALS, SUCH AS THE SPENT ACTIVATED CARBON, WOULD REQUIRE DISPOSAL.

ESTIMATED TIME TO IMPLEMENT 15 YEARS
ESTIMATED CAPITAL COST $242,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST $64,010
ESTIMATED PRESENT WORTH COST (15 YEARS, 10 PERCENT) $730,000

8.2.6 LIQUID PHASE CARBON ADSORPTION ALTERNATIVE (GM-6)

AFTER EXTRACTION, THE GROUND WATER WOULD BE PUMPED THROUGH A FILTER SYSTEM TO REMOVE SUSPENDED PARTICULATES THAT COULD CAUSE CLOGGING OF THE CARBON BED. EFFLUENT FROM THE FILTRATION UNIT WOULD FLOW TO CARBON ADSORPTION UNITS. TREATED EFFLUENT WOULD BE DISCHARGED, AFTER SAMPLING AND MONITORING, TO AN OUTFALL ALONG WILSON ROAD OR RELEASED TO THE LOCAL POTW. THE CARBON ADSORPTION UNITS WOULD REQUIRE RECHARGING AFTER THEIR ADSORPTION CAPACITIES HAD BEEN DEPLETED.

ESTIMATED TIME TO IMPLEMENT 15 YEARS
ESTIMATED CAPITAL COST $218,875
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST $85,000
ESTIMATED PRESENT WORTH COST (15 YEARS, 10 PERCENT) $860,500

8.2.7 ULTRAVIOLET CATALYZED OXIDATION ALTERNATIVE (GM-7)

AFTER EXTRACTION, THE GROUND WATER WOULD BE PUMPED INTO THE OZONE/ULTRAVIOLET (UV) UNIT WHERE HYDROGEN PEROXIDE WOULD BE ADDED AND MIXED, FOLLOWED BY ADDITION OF OZONE. THE MIXTURE WOULD BE SUBJECTED TO ULTRAVIOLET RADIATION WHICH ACTS AS A CATALYST FOR THE OXIDATION REACTION. THE OXIDATION REACTION "STRIPS" VOLATILES FROM THE GROUND WATER. OFF-GASES WOULD BE DECOMPOSED CATALYTICALLY. THIS IS AN INNOVATIVE TECHNOLOGY. A TREATABILITY STUDY WOULD BE REQUIRED. THIS ALTERNATIVE DESTROYS THE CONTAMINANTS RATHER THAN "FIXING" THEM ON CARBON.

ESTIMATED TIME TO IMPLEMENT 15 YEARS
ESTIMATED CAPITAL COST $380,000
ESTIMATED ANNUAL OPERATION AND MAINTENANCE COST $12,000
ESTIMATED PRESENT WORTH COST (15 YEARS, 10 PERCENT) $850,000

#SCA

9.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

THE NCP HAS ESTABLISHED NINE CRITERIA TO BE USED TO EVALUATE REMEDIAL ALTERNATIVES. TO SELECT A REMEDY, EACH ALTERNATIVE MUST BE EVALUATEDWITH REGARD TO THESE CRITERIA AND THEN COMPARED TO EACH OTHER (SEE TABLES 10 AND 11).

THE SELECTED REMEDY IS THAT ALTERNATIVE THAT PROVIDED THE BEST BALANCE OF TRADE-OFFS IN THIS COMPARATIVE ANALYSIS.

EPA HAS DETERMINED THAT THE BEST ALTERNATIVES FOR THE MEW SITE ARE SM-11 (ONSITE INCINERATION) AND GM-5 (AIR-STRIPPING). AS DISCUSSED BELOW, SM-11 AND GM-5 PROVIDE THE BEST BALANCE OF TRADE-OFFS AMONG THE ALTERNATIVES WITH RESPECT TO THE NINE CRITERIA.

THE NCP PRIORITIZES THE NINE CRITERIA INTO THREE CATEGORIES. THE FIRST SUCH CATEGORY IS THRESHOLD CRITERIA. AN ALTERNATIVE MUST MEET THE FOLLOWING TWO REQUIREMENTS TO BE CONSIDERED AS A FINAL REMEDY FOR THE SITE:

9.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

THE SELECTED REMEDY FOR SOIL CONTAMINATION IS TO EXCAVATE AND THERMALLY DESTROY THE PCB-CONTAMINATED SOILS. THE SELECTED REMEDY FOR GROUND WATER CONTAMINATION IS TO EXTRACT THE CONTAMINATED WATER AND TREAT IT BY AIR-STRIPPING FOLLOWED BY VAPOR PHASE CARBON ADSORPTION. THESE ALTERNATIVES WILL REDUCE THE EXPOSURE TO CONTAMINATED SOILS AND GROUND WATER TO PROTECTIVE LEVELS AND ALSO MINIMIZE THE POTENTIAL FOR CONTAMINANT MIGRATION.

THE NO ACTION (SM-1/GM-1) AND SOIL LIMITED ACTION (SM-2) ALTERNATIVES AND THE ASPHALT CAP ALTERNATIVE (SM-4) DO NOT PROVIDE OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT. THESE ALTERNATIVES RELY ON PHYSICAL BARRIERS AND INSTITUTIONAL CONTROLS TO REDUCE OR MINIMIZE THE THREAT OF CONTACT WITH THE CONTAMINATED MATERIALS. THEY DO NOT SIGNIFICANTLY REDUCE THE RISKS TO HUMAN HEALTH OR THE ENVIRONMENT REPRESENTED BY SITE CONDITIONS, AND THEREFORE UNACCEPTABLE RESIDUAL RISK REMAINS.

THE SOIL ALTERNATIVES (SM-1, SM-2, AND SM-4) DO NOT PROVIDE ANY TECHNOLOGY WHICH WOULD TREAT THE PCB CONTAMINATION TO DECREASE ITS TOXICITY, MOBILITY OR VOLUME. THE PCB CONTAMINATION WOULD NOT BE REDUCED WITH DIRECT CONTACT LIMITED ONLY BY AN ASPHALT CAP OR PERIMETER FENCING. THE FENCE WOULD NOT PROVIDE A BARRIER TO MIGRATION OF THE CONTAMINATED SOILS BY EITHER WIND OR RUNOFF. CRACKING AND DETERIORATION OF THE CAP WOULD EXPOSE THE UNDERLYING CONTAMINATED SOILS. CONSTRUCTION OF A CAP WOULD REQUIRE GREATER USE OF INSTITUTIONAL CONTROLS AND THE POTENTIAL FOR EXPOSURE WOULD STILL EXIST. THE SOURCE OF VOC CONTAMINATION TO THE GROUND WATER WOULD NOT BE REMOVED BY CAPPING THE SITE.

THE NO ACTION GROUND WATER ALTERNATIVE IN UNACCEPTABLE BECAUSE OF THE UNCERTAINTY OF POSSIBLE EXPOSURES. AVAILABLE INFORMATION ON REGIONAL GEOLOGIC CONDITIONS INDICATES THAT THERE IS NOT A BARRIER IN THE LIMESTONE BEDROCK TO PREVENT DOWNWARD MIGRATION OF THE CONTAMINATION FOR A DEPTH OF APPROXIMATELY 1,000 FEET. SHOULD NO GROUND WATER BARRIER BE PRESENT, THE EXPOSURE AND POTENTIAL EXPOSURE TO CONTAMINATED GROUND WATER HAS NOT BEEN ADEQUATELY ADDRESSED.

THE GROUND WATER LIMITED ACTION ALTERNATIVE (GM-2) MAY BE CONSIDERED TO BE PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT. WHILE IT RELIES ON INSTITUTIONAL CONTROLS AND PHYSICAL BARRIERS TO MINIMIZE THE THREAT OF CONTACT WITH THE CONTAMINATED MATERIALS, IT ALSO INCORPORATES FREQUENT MONITORING OF THE GROUND WATER CONDITIONS. THE MONITORING DATA WOULD BE USED TO INDICATE IF THE CONTAMINATION IS POSING ADDITIONAL RISK TO HUMAN HEALTH OR THE ENVIRONMENT.

SOIL ALTERNATIVES SM-8, SM-10 AND SM-11, ALL USE TECHNOLOGIES THAT WOULD DESTROY THE PCBS BOUND TO THE SOILS AND SEDIMENTS. INSTITUTIONAL CONTROLS, SUCH AS DEED RESTRICTIONS, WOULD BE REQUIRED FOR THE RESIDUALLY CONTAMINATED PROPERTY BECAUSE THE RESIDUAL CONCENTRATIONS WOULD RESULT IN UNACCEPTABLE RISK LEVELS FOR RESIDENTIAL USE. HOWEVER, WITH INSTITUTIONAL CONTROLS THERE WOULD BE NO LONG-TERM RISK ABOVE ACCEPTABLE LEVELS. THESE TECHNOLOGIES WOULD RESULT IN THE PERMANENT ELIMINATION OF THE RISKS POSED BY THE PCB CONTAMINATION.

GROUND WATER ALTERNATIVES GM-5, GM-6 AND GM-7 WOULD PROVIDE PERMANENT ELIMINATION OF THE RISKS POSED BY THE GROUND WATER CONTAMINATION BY REMOVAL AND DESTRUCTION OF THE VOLATILE ORGANIC COMPOUNDS. THE LONG-TERM RESIDUAL RISK WOULD BE BELOW ACCEPTABLE LEVELS.

SOIL ALTERNATIVE SM-7 WOULD PROVIDE LONG-TERM REDUCTION OF RISKS PRESENTED BY DIRECT CONTACT WITH PCBS. HOWEVER, THE 99+ PERCENT DESTRUCTION OF PCBS IN THE SOIL AND SEDIMENT IS CONSIDERED TO BE MORE PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT THAN SIMPLY ENCAPSULATING THE CONTAMINATION IN A STABILIZED SOIL MONOLITH.

NEITHER SOIL ALTERNATIVE SM-4 NOR GROUND WATER ALTERNATIVE GM-3 WOULD PERMANENTLY ELIMINATE RESIDUAL RISK.

9.2 COMPLIANCE WITH ARARS

THE SELECTED REMEDIES WILL COMPLY WITH ALL FEDERAL AND STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS). APPLICABLE REQUIREMENTS ARE THOSE STATE OR FEDERAL REQUIREMENTS LEGALLY APPLICABLE TO THE RELEASE OR REMEDIAL ACTION CONTEMPLATED THAT SPECIFICALLY ADDRESS A HAZARDOUS SUBSTANCE, POLLUTANT, CONTAMINANT, REMEDIAL ACTION, LOCATION OR OTHER CIRCUMSTANCE FOUND AT THE SITE. IF IT IS DETERMINED THAT A REQUIREMENT IS NOT APPLICABLE, IT MAY STILL BE RELEVANT AND APPROPRIATE TO THE CIRCUMSTANCES OF THE RELEASE. REQUIREMENTS ARE RELEVANT AND APPROPRIATE IF THEY ADDRESS PROBLEMS OR SITUATIONS SUFFICIENTLY SIMILAR TO THE CIRCUMSTANCES OF THE RELEASE OR REMEDIAL ACTION CONTEMPLATED AND ARE WELL-SUITED TO THE SITE.

CHEMICAL-SPECIFIC ARARS ASSOCIATED WITH THE SITE INCLUDE THE TOXIC SUBSTANCES CONTROL ACT; THE NATIONAL AMBIENT AIR QUALITY STANDARDS; AND THE NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS. ALSO IDENTIFIED AS ARARS FOR THE SITE ARE THE MISSOURI STATE WATER QUALITY STANDARDS. AS AN EPA POLICY, THE TSCA PCB SPILL CLEANUP POLICY, 40 CFR PART 761, IS TO BE CONSIDERED IN EVALUATING ALTERNATIVES.

NO FEDERAL LOCATION-SPECIFIC ARARS WERE IDENTIFIED FOR THE SITE. HOWEVER, THE PRESENCE OF A WETLAND SOUTH OF THE SITE MUST BE CONSIDERED AS THE SELECTED REMEDY CANNOT ADVERSELY AFFECT THE WETLAND AREA. A STATE LOCATION-SPECIFIC ARAR, PROTECTION OF LAKES AND STREAMS, MISSOURI WATER QUALITY STANDARDS (10 CSR 20-7.031), WAS IDENTIFIED FOR THE SITE.

THE FEDERAL ACTION-SPECIFIC ARARS FOR THE SITE ARE: ALL PERTINENT OCCUPATIONAL SAFETY AND HEALTH ACT REQUIREMENTS; THE CLEAN WATER ACT REGULATIONS APPLICABLE TO DISCHARGES TO POTWS; ALL PERTINENT REQUIREMENTS IN THE TOXIC SUBSTANCES AND CONTROL ACT, INCLUDING ITS LAND DISPOSAL AND INCINERATOR STANDARDS FOR PCBS; AND THE CLEAN AIR ACT REQUIREMENTS APPLICABLE TO INCINERATORS. TSCA REQUIRES THAT THERMAL TREATMENT DESTROY PCBS AT AN EFFICIENCY OF 99.9999 PERCENT WITH LESS THAN 2 PPM RESIDUAL CONCENTRATION OF PCBS IN THE ASH. A TRIAL BURN WILL BE CONDUCTED TO DEMONSTRATE THAT THIS REQUIREMENT CAN BE SATISFIED.

THE NO ACTION AND LIMITED ACTION ALTERNATIVES FOR SOIL AND GROUND WATER DO NOT SATISFY CHEMICAL-SPECIFIC ARARS. NOR DOES ALTERNATIVE GM-3 (EXTRACTION OF GROUND WATER WITH DISCHARGE TO SURFACE WATER).

OFFSITE LANDFILLING OF THE EXCAVATED SOILS, ONSITE STABILIZATION/FIXATION, SOLVENT EXTRACTION, AND IN-SITU VITRIFICATION (SOIL ALTERNATIVES SM-6, SM-7, SM-8, AND SM-10) AND GROUND WATER ALTERNATIVES GM-4, GM-6 AND GM-7 (EXTRACTION WITH DISCHARGE TO POTW, LIQUID PHASE CARBON ADSORPTION, AND ULTRAVIOLET CATALYZED OXIDATION) WOULD MEET THE CHEMICAL-SPECIFIC, ACTION-SPECIFIC AND LOCATION-SPECIFIC ARARS IDENTIFIED IN APPENDIX A.

SIX ALTERNATIVES, THREE SOIL AND THREE GROUND WATER, DID NOT MEET THRESHOLD CRITERIA. SPECIFICALLY, THESE ALTERNATIVES ARE: NO ACTION FOR BOTH SOILS AND GROUND WATER (SM-1 AND GM-1); LIMITED ACTION FOR BOTH SOILS AND GROUND WATER (SM-2 AND GM-2); ASPHALT CAP FOR SOILS (SM-4); AND GROUND WATER EXTRACTION WITH DISCHARGE TO SURFACE WATER (GM-3). BECAUSE THESE ALTERNATIVES DID NOT MEET THRESHOLD CRITERIA, THEY WERE NOT CONSIDERED FURTHER IN THE COMPARATIVE ANALYSIS OF ALTERNATIVES.

THE SECOND CATEGORY OF CRITERIA IS PRIMARY BALANCING CRITERIA. THE FOLLOWING FIVE CRITERIA ARE USED TO EVALUATE THE ALTERNATIVES TO DETERMINE THE OPTION THAT PROVIDES THE BEST BALANCE OF TRADE-OFFS FOR THE SITE.

9.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

THE SELECTED REMEDIES WILL ELIMINATE LONG-TERM RISKS ASSOCIATED WITH DIRECT CONTACT AND POTENTIAL MIGRATION OF CONTAMINANTS BY DESTROYING THE PCB CONTAMINATION THROUGH INCINERATION OF THE SOILS ONSITE AND BY PERMANENTLY REMOVING AND DESTROYING THE VOC CONTAMINATION IN THE GROUND WATER BY AIR-STRIPPING FOLLOWED THROUGH CARBON ADSORPTION.

SOLVENT EXTRACTION AND IN-SITU VITRIFICATION OF THE SOIL (SOIL ALTERNATIVES SM-8 AND SM-10), BOTH INVOLVE TREATMENT TO DESTROY OR REMOVE THE PCB-MOLECULES. THESE ALTERNATIVES WOULD ALSO ELIMINATE THE RISKS ASSOCIATED WITH THE PCB-CONTAMINATION.

SOIL ALTERNATIVE SM-7 (STABILIZATION/FIXATION) WOULD IMMOBILIZE THE PCB-CONTAMINATED SOILS BY STABILIZING THEM. HOWEVER, THE PCBS WOULD NOT BE DESTROYED. ACCORDINGLY, LONG-TERM MONITORING, MAINTENANCE AND INSTITUTIONAL CONTROLS WOULD BE REQUIRED. DEGRADATION OF THE SOIL COVER OVER THE STABILIZED SOILS COULD EXPOSE THE MONOLITH TO PRECIPITATION RUNOFF (EROSIVE FORCES), AND FREEZE/THAW AND WET/DRY CYCLES. THESE FORCES HAVE BEEN SHOWN TO ADVERSELY AFFECT THE INTEGRITY OF STABILIZED SOILS. MOREOVER, THE SITE IS LOCATED IN A SEISMIC AREA. AS A RESULT THE INTEGRITY OF THE MONOLITH COULD BE ADVERSELY AFFECTED BY AN EARTHQUAKE.

OFFSITE LANDFILLING OF THE CONTAMINATED SOILS (SOIL ALTERNATIVE SM-6), WOULD REMOVE THE CONTAMINATED SOILS FROM THE SITE. HOWEVER, LONG-TERM EFFECTIVENESS OF THIS ALTERNATIVE IS QUESTIONABLE SINCE LANDFILLING DOES NOT DESTROY OR TREAT THE CONTAMINANTS.

GROUND WATER ALTERNATIVES GM-4 (EXTRACTION WITH DISCHARGE TO POTW), GM-6 (EXTRACTION WITH LIQUID PHASE CARBON ADSORPTION) AND GM-7 (EXTRACTION WITH ULTRAVIOLET CATALYZED OXIDATION) WOULD REMOVE AND TREAT THE CONTAMINANTS. HOWEVER, LONG-TERM EFFECTIVENESS AT THE PLACE OF DISPOSAL FOR GM-4 IS QUESTIONABLE BECAUSE THE TREATMENT OF THE GROUND WATER CONTAMINATION WOULD NOT BE DIRECTLY CONTROLLED BY EPA. ALTERNATIVES GM-6 AND GM-7 WOULD PROVIDE LONG-TERM PROTECTION.

9.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME

THE SELECTED REMEDIES WILL ACHIEVE REDUCTION OF TOXICITY, MOBILITY, AND VOLUME OF CONTAMINANTS AT THE SITE.

SOIL ALTERNATIVES SM-8 AND SM-10 (SOLVENT EXTRACTION AND IN-SITU VITRIFICATION) WOULD TREAT THE CONTAMINATED SOILS TO ACHIEVE A REDUCTION IN TOXICITY, MOBILITY AND VOLUME. SOLVENT EXTRACTION WOULD REMOVE THE PCBS FROM THE SOILS AND CONSOLIDATE THEM IN A LIQUID FORM. THE LIQUID WOULD BE INCINERATED OFFSITE, THEREBY DESTROYING THE PCBS. IN-SITU VITRIFICATION WOULD DESTROY THE MAJORITY OF THE PCB CONTAMINATION BY SUBJECTING IT TO HIGH TEMPERATURES. HOWEVER, THE TECHNOLOGY HAS NOT BEEN APPROVED BY TSCA AS A TECHNOLOGY EQUIVALENT TO INCINERATION OR LANDFILLING IN A PERMITTED CHEMICAL WASTE LANDFILL. THE RESIDUAL CONTAMINATION WOULD BE ENCAPSULATED IN A VITRIFIED MASS, SIMILAR TO VOLCANIC GLASS. A VOLUME REDUCTION OF 20 TO 40 PERCENT IS EXPECTED WITH IN-SITU VITRIFICATION.

AS STATED ABOVE, SOIL ALTERNATIVE SM-7 (STABILIZATION/ FIXATION) WOULD RESULT IN A REDUCTION IN THE MOBILITY OF THE PCBS. HOWEVER, THERE WOULD BE NO REDUCTION IN THE TOXICITY OF THE PCBS. MOREOVER, IT WOULD RESULT IN AN INCREASE IN THE VOLUME OF PCB-CONTAMINATED MATERIALS.

SOIL ALTERNATIVE SM-6 (OFFSITE LANDFILLING) PROVIDES NO REDUCTION IN THE MOBILITY, TOXICITY OR VOLUME. IT MERELY MOVES THE CONTAMINATION FROM THE SITE TO A PERMITTED CHEMICAL WASTE LANDFILL.

GROUND WATER ALTERNATIVES GM-4, GM-6, AND GM-7 WOULD TREAT THE CONTAMINATED GROUND WATER TO ACHIEVE A REDUCTION IN TOXICITY, MOBILITY AND VOLUME. LIQUID PHASE CARBON ADSORPTION (GM-6) WOULD REDUCE THE TOXICITY, MOBILITY AND VOLUME OF THE CONTAMINANTS BY CAPTURING THE VOCS ON AN ACTIVATED CARBON FILTER AND THEN "RECHARGING" THE SPENT FILTER WITH THERMAL TREATMENT WHICH WILL DESTROY THE VOCS. ULTRAVIOLET CATALYZED OXIDATION (GM-7) WOULD REDUCE THE TOXICITY, MOBILITY AND VOLUME OF THE VOCS BY SUBJECTING THEM TO A CHEMICAL REACTION PROCESS WHICH WILL DESTROY THE VOCS PRESENT IN THE GROUND WATER.

9.5 SHORT-TERM EFFECTIVENESS

THE SHORT-TERM RISKS ASSOCIATED WITH THE SELECTED REMEDIES WOULD INCLUDE THE NORMAL CONSTRUCTION HAZARDS ASSOCIATED WITH EXCAVATION OF CONTAMINATED SOILS AND CONSTRUCTION OF WELLS AND INSTALLATION OF A FILTRATION SYSTEM. WORKERS ONSITE COULD BE EXPOSED TO CONTAMINATED SOILS AND GROUND WATER; THESE EXPOSURES CAN BE REDUCED AND CONTROLLED BY USE OF APPROPRIATE HEALTH AND SAFETY PROCEDURES.

THERE ARE RISKS ASSOCIATED WITH INCINERATOR OPERATION. IMPROPER OPERATION OF THE INCINERATOR REPRESENTS THE PRINCIPAL RISK. HOWEVER, THESE RISKS ARE CONTROLLED BY FREQUENT TESTING OF THE GASEOUS INCINERATOR EMISSIONS AND MONITORING OF THE OPERATIONS. EMPLOYEES INVOLVED WITH THE INCINERATOR OPERATION WILL BE REQUIRED TO WEAR PROTECTIVE CLOTHING AS SAFEGUARDS. AS A RESULT, RISKS TO THE PUBLIC AND THE ENVIRONMENT CAN BE EFFECTIVELY MINIMIZED.

THE PREFERRED SOIL ALTERNATIVE WOULD REQUIRE APPROXIMATELY ONE TO TWO YEARS TO COMPLETE. THE TIME ESTIMATE FOR INSTALLATION OF WELLS AND FILTRATION SYSTEM IS TWO MONTHS. THE TIME REQUIRED TO ACHIEVE A REDUCTION IN CONTAMINANT LEVELS TO HEALTH-BASED LEVELS IN THE GROUND WATER IS UNCERTAIN, BUT IS EXPECTED TO TAKE APPROXIMATELY 15 YEARS. HOWEVER, EXTRACTION OF

THE GROUND WATER SHOULD PRECLUDE MIGRATION OF THE CONTAMINANT PLUME.

ALL OTHER ALTERNATIVES WOULD ALSO HAVE MINIMAL SHORT-TERM RISKS AS DESCRIBED ABOVE. HOWEVER, AS PREVIOUSLY NOTED, COMPLIANCE WITH THE ACTION-SPECIFIC ARARS WOULD EFFECTIVELY MINIMIZE AND CONTROL THE EXPOSURES.

THE REMAINING SOIL ALTERNATIVES WOULD TAKE ABOUT TWO MONTHS FOR EXCAVATION AND STOCKPILING OF THE SOILS. SOIL ALTERNATIVE SM-6 WOULD BE ESSENTIALLY COMPLETE AT THE END OF THE TWO-MONTH TIME PERIOD. IT IS ESTIMATED THAT SOIL ALTERNATIVES SM-7, SM-8, AND SM-10 WOULD REQUIRE APPROXIMATELY ONE YEAR TO IMPLEMENT. ALL GROUND WATER ALTERNATIVES WOULD TAKE SIMILAR AMOUNTS OF TIME (ESTIMATE: 15 YEARS) TO IMPLEMENT.

9.6 IMPLEMENTABILITY

IMPLEMENTATION OF THE SELECTED REMEDIES WOULD INVOLVE USE OF CONVENTIONAL CONSTRUCTION TECHNIQUES AND PROVEN TECHNOLOGIES FOR THE WASTES BEING TREATED. THE RELIABILITY AND ADEQUACY OF CONTROLS ON MOBILE INCINERATION UNITS HAVE BEEN ESTABLISHED THROUGH PILOT AND FULL-SCALE TESTS AT SEVERAL SITES. MOBILE INCINERATION UNITS ARE CURRENTLY AVAILABLE FROM SEVERAL VENDORS. AIR-STRIPPING OF THE WATER FOLLOWED BY CARBON ADSORPTION OF THE VAPOR PHASE IS A PROCESS USED FREQUENTLY TO TREAT CONTAMINATED GROUND WATER.

SOIL ALTERNATIVE SM-7 WOULD REQUIRE TREATABILITY STUDIES TO IDENTIFY AND DETERMINE THE OPTIMUM MIXTURES OF THE STABILIZATION AND/OR FIXATION AGENTS TO BE USED. THESE TREATABILITY STUDIES WOULD PROBABLY BE PERFORMED IN TWO OR MORE PHASES. THE FIRST PHASE WOULD BE TO IDENTIFY THE MOST EFFECTIVE STABILIZATION AND FIXATION AGENTS. THE SECOND AND ANY FOLLOWING PHASES WOULD BE NEEDED TO IDENTIFY THE OPTIMUM MIXTURES OR RATIOS OF THE STABILIZATION/FIXATION ADDITIVES.

SOIL ALTERNATIVE SM-8 WOULD REQUIRE A TREATABILITY STUDY TO EVALUATE THE EFFECTIVENESS AND IMPLEMENTABILITY OF THE PROCESS FOR SITE-SPECIFIC SOILS. THE EQUIPMENT FOR THIS PROCESS IS AVAILABLE FROM A LIMITED NUMBER OF CONTRACTORS. IF EQUIPMENT IS UNAVAILABLE AT THE TIME OF REMEDIAL ACTION, THEN DELAYS WOULD RESULT.

BENCH AND PILOT SCALE TESTS FOR SIMILAR CASES INDICATE THAT THE TECHNOLOGY USED IN SOIL ALTERNATIVE SM-10 (IN-SITU VITRIFICATION) WOULD LIKELY BE EFFECTIVE FOR THE MEW SITE. POWER NEEDS FOR THIS ALTERNATIVE ARE READILY AVAILABLE. HOWEVER, ONLY ONE VENDOR IS LICENSED TO USE THE TECHNOLOGY AND IT CURRENTLY HAS ONLY ONE UNIT. THIS COULD CAUSE DELAYS AT THE TIME OF REMEDIAL ACTION.

ANALYTICAL TESTING OF THE GROUND WATER WOULD BE REQUIRED FOR GROUND WATER ALTERNATIVE GM-4. THE TESTING WOULD BE NEEDED PRIOR TO THE LOCAL POTW AGREEING TO ACCEPT THE GROUND WATER FOR TREATMENT AND PROCESSING.

GROUND WATER ALTERNATIVE GM-6 (LIQUID PHASE CARBON ADSORPTION) IS A PROVEN TECHNOLOGY. THE EQUIPMENT AND MATERIALS NEEDED TO EFFECT THIS REMEDIAL ALTERNATIVE ARE READILY AVAILABLE. IT SHOULD BE IMPLEMENTED RELATIVELY EASILY.

GROUND WATER ALTERNATIVE GM-7 (ULTRAVIOLET CATALYZED OXIDATION) WOULD REQUIRE TREATABILITY STUDIES TO IDENTIFY ANY SITE-SPECIFIC OPERATIONAL PROBLEMS PRIOR TO IMPLEMENTATION. HANDLING OF THE HYDROGEN PEROXIDE COULD REPRESENT SOME POTENTIAL PROBLEMS; HOWEVER, USE OF STANDARD INDUSTRIAL PROCEDURES SHOULD MINIMIZE ANY PROBLEMS AND ARE CONSIDERED SAFE. THE EQUIPMENT USED FOR THIS TECHNOLOGY IS FRAGILE AND MAY NEED TO BE REPLACED DURING IMPLEMENTATION.

9.7 COST

THE COSTS OF THE SELECTED REMEDIES WOULD INCLUDE THE COSTS ASSOCIATED WITH ONSITE THERMAL TREATMENT, $8.4 MILLION, AND THE COSTS FOR AIR-STRIPPING FOLLOWED BY CARBON TREATMENT OF THE GROUND WATER, $730,000. THESE COSTS REFLECT THE ESTIMATED PRESENT WORTH OF PUMPING AND TREATING GROUND WATER FOR 15 YEARS.

THE RANGE OF PRESENT WORTH COSTS FOR THE SOIL ALTERNATIVES IS $4.4 MILLION FOR SOIL ALTERNATIVE SM-7 TO $11.1 MILLION FOR SOIL ALTERNATIVE SM-10. THE ESTIMATED PRESENT WORTH FOR THE REMAINING GROUND WATER ALTERNATIVES IS $850,000 FOR ALTERNATIVE GM-7 AND $1.1 MILLION FOR ALTERNATIVE GM-4. BOTH SELECTED REMEDIES ACHIEVE PERMANENT REDUCTION IN THE TOXICITY, MOBILITY AND VOLUME OF CONTAMINANTS AT COSTS THAT ARE PROPORTIONAL TO THEIR OVERALL EFFECTIVENESS.

THE FOLLOWING SUMMARY IS PROVIDED OF THE EVALUATION OF THE SOIL AND GROUND WATER ALTERNATIVES WITH RESPECT TO THE FIVE PRIMARY BALANCING CRITERIA:

SOILS/SEDIMENTS

ALTERNATIVES SM-8, SM-10 AND SM-11 (SOLVENT EXTRACTION, IN-SITU VITRIFICATION, AND ONSITE INCINERATION) WOULD PERFORM EQUALLY WITH RESPECT TO LONG-TERM EFFECTIVENESS; ALTERNATIVES SM-7 AND SM-6 (STABILIZATION/FIXATION AND OFFSITE LANDFILL) WOULD PROVIDE LESS PERMANENT LONG-TERM EFFECTIVENESS. ALTERNATIVES SM-7, SM-8, SM-10, AND SM-11 WOULD ALL REDUCE THE MOBILITY OF THE PCB CONTAMINANTS; SM-6 WOULD NOT REDUCE CONTAMINANT MOBILITY. TOXICITY AND VOLUME OF THE PCB CONTAMINANTS WOULD BE REDUCED BY ALTERNATIVES SM-8, SM-10 AND SM-11; NO TOXICITY REDUCTION WOULD BE ACHIEVED BY SM-6 OR SM-7. ALTERNATIVE SM-6 AFFORDS NO VOLUME REDUCTION OF THE PCB CONTAMINANTS, WHILE SM-7 WOULD RESULT IN AN INCREASE IN THE VOLUME OF PCB-CONTAMINATED MATERIAL. ALL SOIL ALTERNATIVES CONSIDERED IN CONJUNCTION WITH THE PRIMARY BALANCING CRITERIA WOULD PROVIDE SHORT-TERM EFFECTIVENESS. ALTERNATIVE SM-10 HAS NOT BEEN USED FOR A FULL-SCALE SITE CLEANUP; PROBLEMS WITH THIS TECHNOLOGY COULD ARISE WHICH WOULD DECREASE ITS ABILITY TO BE IMPLEMENTED. ALTERNATIVE SM-8 MAY NOT BE EFFECTIVE GIVEN THE COHESIVE NATURE OF THE SITE SOILS. RESIDUAL SOLVENT CONCENTRATIONS COULD REMAIN IN THE SOILS MAKING IT LESS ATTRACTIVE. ALTERNATIVE SM-7 IS THE LEAST EXPENSIVE SOIL ALTERNATIVE WITH A COST OF $4.4 MILLION. SOIL ALTERNATIVE SM-10 IS THE MOST EXPENSIVE WITH A COST OF $11.1 MILLION. ONSITE INCINERATION COSTS FALL IN THE MIDDLE OF THE COSTS FOR THE ALTERNATIVES CONSIDERED. THIS REMEDY PROVIDES THE BEST BALANCE OF TRADE-OFFS AMONG THE ALTERNATIVES, PARTICULARLY WITH RESPECT TO LONG-TERM EFFECTIVENESS AND THE PERMANENT REDUCTION OF TOXICITY, MOBILITY AND VOLUME.

GROUND WATER

GROUND WATER ALTERNATIVES GM-5, GM-6, AND GM-7 WERE CONSIDERED TO PERFORM EQUALLY WITH RESPECT TO LONG-TERM EFFECTIVENESS; ALTERNATIVE GM-4 WAS CONSIDERED TO BE POTENTIALLY LESS EFFECTIVE OVER THE LONG-TERM SINCE LESS CONTROL OVER THE PROCESS WOULD BE EXERCISED BY EPA OR THE MEWSC. ALL GROUND WATER ALTERNATIVES CONSIDERED WERE JUDGED TO PROVIDE EQUAL REDUCTION OF MOBILITY, TOXICITY AND VOLUME OF THE VOC CONTAMINATION. THE SHORT-TERM EFFECTIVENESS OF ALL GROUND WATER ALTERNATIVES WAS CONSIDERED TO BE EQUAL. ALL GROUND WATER ALTERNATIVES CAN BE IMPLEMENTED.

GW-5 (AIR-STRIPPING FOLLOWED BY VAPOR PHASE CARBON ADSORPTION) WAS THE LEAST EXPENSIVE ALTERNATIVE, WITH AN ESTIMATED COST $730,000. ALTERNATIVE GM-4 WAS THE MOST EXPENSIVE WITH AN ESTIMATED COST OF $1.1 MILLION. REMEDY GM-5 PROVIDES THE BEST BALANCE OF TRADE-OFFS AMONG THE GROUND WATER ALTERNATIVES, PARTICULARLY WITH RESPECT TO LONG-TERM EFFECTIVENESS AND PERMANENT REDUCTION IN TOXICITY, MOBILITY AND VOLUME.

THE THIRD CATEGORY OF CRITERIA IS MODIFYING CRITERIA. THE FOLLOWING TWO CRITERIA ARE CONSIDERED WHEN EVALUATING THE ALTERNATIVES AND ARE USED TO HELP DETERMINE THE FINAL REMEDIES FOR THE SITE.

9.8 STATE ACCEPTANCE

THE STATE OF MISSOURI HAS BEEN INFORMED OF EPA'S SELECTED REMEDIES: ONSITE INCINERATION OF THE PCB-CONTAMINATED SOILS AND AIR-STRIPPING FOLLOWED BY VAPOR PHASE CARBON ADSORPTION OF THE VOC-CONTAMINATED GROUND WATER. THE STATE OF MISSOURI HAS OFFICIALLY NOTIFIED EPA OF ITS CONCURRENCE WITH THE SELECTED REMEDIAL ACTIONS.

9.9 COMMUNITY ACCEPTANCE

THE COMMUNITY AND OTHER INTERESTED CITIZENS OR PARTIES WERE GIVEN THE OPPORTUNITY TO REVIEW THE PROPOSED PLAN AND SUPPORTING DOCUMENTS OF THE ADMINISTRATIVE RECORD. A THIRTY-DAY COMMENT PERIOD WAS AVAILABLE FOR THE PUBLIC TO COMMENT ON THESE DOCUMENTS. A PUBLIC HEARING WAS HELD IN CAPE GIRARDEAU ON AUGUST 30, 1990 TO DISCUSS THE PROPOSED PLAN AND THE PREFERRED *REMEDIAL ALTERNATIVES. NO COMMENTS ON THE PROPOSED PLAN WERE RECEIVED AT THAT PUBLIC* HEARING. THERE HAVE BEEN NO COMMENTS INDICATING STRONG OPPOSITION FROM THE GENERAL PUBLIC TO THE PREFERRED ALTERNATIVES IDENTIFIED IN THE PROPOSED PLAN. COMMENTS THAT WERE SUBMITTED ARE ADDRESSED IN THE RESPONSIVENESS SUMMARY.

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10.0 THE SELECTED REMEDY

10.1 SOILS/SEDIMENTS

THE REMEDIAL ACTION SELECTED FOR THE SOIL CLEANUP WILL PROVIDE OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT BY ELIMINATING, REDUCING AND CONTROLLING ALL CURRENT AND POTENTIAL RISKS POSED BY THE EXPOSURE PATHWAYS AT THE SITE, AND WILL BE IN COMPLIANCE WITH ALL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS). THE LONG-TERM EFFECTIVENESS AND PERMANENCE OF THE SELECTED SOIL REMEDY WERE DETERMINED TO BE CRITICAL FACTORS IN BALANCING THE TRADE-OFFS AMONG THE OTHER SOIL ALTERNATIVES.

THE STATUTORY PREFERENCE OF CERCLA S121(B) TO PERMANENTLY AND SIGNIFICANTLY REDUCE THE VOLUME, TOXICITY, OR MOBILITY OF THE HAZARDOUS SUBSTANCES THROUGH TREATMENT TECHNOLOGIES (TO THE MAXIMUM EXTENT PRACTICABLE) IS SATISFIED BY THE SELECTED SOIL REMEDY. THE TECHNOLOGY SELECTED IS A PROVEN TECHNOLOGY. CASE STUDIES OF OTHER CLEANUPS INDICATE THAT ONSITE INCINERATION IS A CONSISTENT PRACTICAL APPROACH TO PERMANENT DESTRUCTION OF PCBS. THIS REMEDY SHOULD BE RELATIVELY EASY TO IMPLEMENT FROM BOTH A TECHNICAL AND ADMINISTRATIVE POINT OF VIEW. MOBILE INCINERATION UNITS ARE AVAILABLE FROM SEVERAL VENDORS AND THEREFORE SHOULD BE READILY AVAILABLE.

THE COST OF IMPLEMENTING THE SELECTED SOIL REMEDY, ONSITE INCINERATION, WAS CONSIDERED DURING EPA'S EVALUATION PROCESS. THE RESULTS OF THIS COMPARATIVE ANALYSIS INDICATED THAT WHILE THE COSTS ASSOCIATED WITH ONSITE INCINERATION DO EXCEED THE COST ASSOCIATED WITH THE OTHER SOURCE CONTROL ALTERNATIVES ANALYZED (STABILIZATION/FIXATION AND SOLVENT EXTRACTION), THESE COSTS ARE PROPORTIONAL TO THE OVERALL GREATER EFFECTIVENESS OF ONSITE INCINERATION.

ROTARY KILN INCINERATORS ARE PROBABLY THE MOST COMMON TYPE OF EQUIPMENT USED FOR MOBILE INCINERATION BECAUSE THEY HAVE BEEN COMMERCIALLY PROVEN, PROVIDE FLEXIBILITY IN HANDLING MANY TYPES OF MATERIALS AND PROVIDE GOOD MIXING AND LONG RESIDENCE TIMES FOR SOLIDS. ROTARY KILNS ARE EQUALLY APPLICABLE TO SOLIDS, SLUDGES, AND SLURRIES AND ARE CAPABLE OF RECEIVING AND PROCESSING LIQUIDS AND SOLIDS SIMULTANEOUSLY. THE FIVE BASIC COMPONENTS OF THE ROTARY KILN SYSTEM ARE: 1) ROTARY KILN (PRIMARY COMBUSTION CHAMBER); 2) SECONDARY COMBUSTION CHAMBER; 3) HEAT RECOVERY BOILER; 4) AIR POLLUTION CONTROL TRAIN; AND 5) EFFLUENT NEUTRALIZATION CHAMBER. THE SOIL IS FED INTO THE ROTARY KILN THAT IS MOUNTED ON AN INCLINE. TEMPERATURES RANGE FROM 1,200 TO 1,800 DEGREES FAHRENHEIT AND THE RESIDENCE TIME DEPENDS ON THE CONTAMINANTS BEING TREATED. TYPICAL FEED RATES FOR SOILS ARE 1,300 TO 1,400 POUNDS PER HOUR. THE SOIL IS REMOVED AT THE LOWER END OF THE KILN AND THE VAPORS DESORBED FROM THE SOIL THEN ENTER THE SECONDARY CHAMBER, AT TEMPERATURES OF 1,500 TO 3,000 DEGREES FAHRENHEIT, TO COMPLETE OXIDATION. AS THE EXHAUST GASES EXIT THE SECONDARY CHAMBER, THEY ARE DIRECTED THROUGH A POLLUTION CONTROL TRAIN WHICH MAY CONSIST OF A WATER QUENCH, A PACKED SCRUBBING TOWER OR AN EJECTION SCRUBBER SYSTEM.

IMPLEMENTATION OF ONSITE INCINERATION AT THE MEW SITE WOULD CONSIST OF THE FOLLOWING TASKS. PREPARATION OF THE SITE WILL BE PERFORMED BY CLEARING TREES AND VEGETATION IN THE AREA WHERE THE INCINERATOR IS TO BE PLACED. CONTAMINATED SOILS WILL BE EXCAVATED AND CONSOLIDATED ONSITE WITH PROVISIONS TO MINIMIZE MIGRATION OF THE CONTAMINATED MATERIALS. THE INCINERATOR WILL BE BROUGHT TO THE SITE, AT WHICH TIME TRIAL BURN(S) WILL BE PERFORMED, TESTED AND EVALUATED BEFORE THE INCINERATION OF THE PCB-CONTAMINATED SOILS WILL BE DONE. WHEN THE

INCINERATION IS COMPLETE, THE INCINERATOR WILL BE REMOVED FROM THE SITE. THE SITE WILL BE RESTORED AND REVEGETATED. FIGURE 11 IS A FLOW-DIAGRAM OF THE PCB-CONTAMINATED SOIL REMEDIAL ACTION.

SITE PREPARATION ACTIVITIES WOULD CONSIST OF CLEARING AN AREA APPROXIMATELY ONE ACRE IN SIZE WHERE THE INCINERATOR WOULD BE SETUP. CONTAMINATED SOILS FROM THIS AREA WOULD BE STOCKPILED IN THE IMMEDIATE VICINITY TO AWAIT PROCESSING WHEN THE INCINERATOR IS IN-PLACE AND OPERATIONAL. A CONCRETE PAD WOULD BE CONSTRUCTED IN THE CLEARED AREA TO SUPPORT THE PROCESSING EQUIPMENT. OTHER SITE PREPARATION ACTIVITIES WOULD INCLUDE REMOVAL OF TREES AND MISCELLANEOUS TRASH AND DEBRIS PRESENT ON THE SITE IN THOSE AREAS WITH PCB LEVELS GREATER THAN 10 PPM.

EXCAVATION AND CONSOLIDATION OF ALL ON AND OFFSITE CONTAMINATED SOILS WITH PCB CONCENTRATIONS GREATER THAN 10 PPM WOULD HAVE TO BE PERFORMED. EXCAVATION OF THE SOILS AND ANY OTHER CONTAMINATED MATERIALS WOULD BE ACCOMPLISHED USING CONVENTIONAL HEAVY CONSTRUCTION EQUIPMENT. EXCAVATED MATERIALS WOULD BE STAGED FOR PROCESSING NEAR THE INCINERATOR IN STOCKPILES. THESE STOCKPILES WOULD BE ESTABLISHED, WITH APPROPRIATE RUNOFF AND WIND DISPERSION PROTECTIVE DEVICES, FOR BOTH CONTAMINATED FEED MATERIALS (CONTAMINATED SOILS) AND THE PROCESS RESIDUALS. THE RESIDUALS WOULD BE USED TO BACKFILL THE ONSITE EXCAVATED AREAS. CLEAN SOILS WOULD PROBABLY BE REQUIRED TO COMPLETE SITE RESTORATION AND FINAL GRADING.

PERMITTING FOR THE ONSITE INCINERATOR WILL NOT BE REQUIRED, AS THIS REMEDIAL ACTION WILL BE PERFORMED ONSITE. HOWEVER, A TRIAL BURN WILL BE REQUIRED, AS WILL FREQUENT MONITORING AND ANALYTICAL TESTS, TO ESTABLISH THAT THE INCINERATOR COMPLIES WITH ALL SUBSTANTIVE REQUIREMENTS APPLICABLE TO A TSCA INCINERATOR.

AFTER CONSTRUCTING THE CONCRETE PAD IN THE PROCESSING AREA, THE INCINERATOR WILL BE MOBILIZED TO THE SITE. THE INCINERATOR WILL BE BROUGHT TO THE SITE USING HIGHWAY OR RAILROAD CONVEYANCES. UPON ARRIVAL AT THE SITE, THE INCINERATOR WILL BE SETUP IN ITS WORKING CONFIGURATION.

A TRIAL BURN WILL BE PERFORMED AFTER INCINERATION SET-UP IS COMPLETE. THE PRIMARY REASON FOR A TRIAL BURN IS TO PROVIDE DATA, BOTH OPERATIONAL AND ANALYTICAL, THAT VERIFIES THAT THE INCINERATOR COMPLIES WITH ALL SUBSTANTIVE REQUIREMENTS OF A PERMITTED TSCA INCINERATOR. IN ADDITION, THE DATA GENERATED WILL BE USED TO IDENTIFY THE RESIDENCE TIME NEEDED TO MEET PCB DESTRUCTION REQUIREMENTS AND TO MONITOR THE EMISSIONS FROM THE INCINERATOR.

AFTER THE DATA GENERATED BY THE TRIAL BURN HAS BEEN REVIEWED AND EVALUATED BY STATE AND FEDERAL AUTHORITIES, APPROVAL TO BEGIN "PRODUCTION-TYPE" OPERATIONS WILL BE GIVEN, IF ALL SUBSTANTIVE REQUIREMENTS OF A PERMITTED UNIT HAVE BEEN MET. OPERATIONS WILL CONSIST OF SIZING OF THE STOCK-PILED CONTAMINATED MATERIALS IN PREPARATION FOR INCINERATION. THESE SIZED MATERIALS WILL BE FED INTO THE INCINERATOR USING EQUIPMENT SIMILAR TO A PUG-MILL. FEED RATES WILL BE MONITORED CONTINUOUSLY. EMISSIONS FROM THE INCINERATOR, BOTH ASH AND GASES, WILL BE MONITORED FREQUENTLY (NOT LESS THAN DAILY) TO DOCUMENT THAT DESTRUCTION EFFICIENCIES AND AIR EMISSIONS STANDARDS ARE COMPLIED WITH. IN ADDITION, THE ASH RESIDUALS WILL BE TESTED TO IDENTIFY ITS LEACHING CHARACTERISTICS AND TO IDENTIFY THE COMPOUNDS WITHIN THE ASH. THE LEACHING CHARACTERISTICS WILL BE IDENTIFIED USING THE TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP).

AFTER THE PCB-CONTAMINATED SOILS AND OTHER MATERIALS HAVE BEEN DESTROYED BY INCINERATION, THE INCINERATOR AND OTHER APPURTENANT EQUIPMENT WILL BE DEMOBILIZED AND REMOVED FROM THE SITE. THE CONCRETE PAD WILL BE TESTED TO ASCERTAIN WHETHER IT WAS CONTAMINATED DURING INCINERATION OPERATIONS. IF IT IS NOT CONTAMINATED, THE CONCRETE PAD WILL BE REMOVED AND DISPOSED OF IN A SANITARY LANDFILL. IF THE CONCRETE PAD IS FOUND TO BE CONTAMINATED, DISPOSAL IN A LICENSED CHEMICAL WASTE LANDFILL WILL BE NECESSARY.

AS THE RESIDUAL ASH FROM INCINERATION OPERATIONS IS PRODUCED AND TESTED, IT WILL BE USED TO BACKFILL THE EXCAVATED AREAS ON THE MISSOURI ELECTRIC WORKS, INC., PROPERTY. THE RESIDUAL ASH WILL BE SPREAD AND COMPACTED USING CONVENTIONAL HEAVY CONSTRUCTION EQUIPMENT. SOIL, THAT HAS BEEN VERIFIED AS BEING UNCONTAMINATED WITH ANALYTICAL TESTS, WILL BE USED TO BACKFILL

OTHER PORTIONS OF THE SITE. THE ENTIRE SITE WILL BE RESTORED TO ITS ORIGINAL GRADE USING THIS VERIFIED "CLEAN" MATERIAL. THE SOIL WILL BE SPREAD AND COMPACTED USING CONVENTIONAL MEANS.

THE FINAL GRADING OF THE SITE WILL BE SUCH THAT THE NATURAL DRAINAGE OF THE SITE IS CONTROLLED OR MANAGED. THIS WILL BE DONE TO ENSURE THAT EROSIONAL FEATURES, SIMILAR TO THOSE PRESENTLY EXISTENT AT THE SITE, DO NOT REFORM.

A 6- TO 12-INCH LAYER OF TOPSOIL WILL BE SPREAD OVER THE ENTIRE SITE. THIS TOPSOIL WILL BE SEEDED OR SOD WILL BE PLACED TO REVEGETATE THE SITE.

INSTITUTIONAL CONTROLS, SUCH AS DEED RESTRICTIONS AND/OR ZONING RESTRICTIONS WILL BE IMPOSED TO LIMIT USE OF THE SITE TO INDUSTRIAL OR COMMERCIAL PURPOSES.

10.2 GROUND WATER

THE SELECTED GROUND WATER REMEDY WILL PROVIDE OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT BY REDUCING AND CONTROLLING ALL POTENTIAL RISKS POSED BY INGESTION OF THE GROUND WATER. THE SELECTED REMEDY WILL COMPLY WITH ALL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS). THE SELECTED REMEDY WILL USE A PROVEN TECHNOLOGY THAT IS READILY AVAILABLE FROM SEVERAL VENDORS AT A COSTS THAT IS PROPORTIONAL TO ITS OVERALL EFFECTIVENESS.

THIS REMEDIAL TECHNOLOGY INVOLVES COLLECTION OF GROUND WATER UTILIZING AN EXTRACTION WELL NETWORK, TEMPORARY STORAGE, FOLLOWED BY REMOVAL OF VOLATILE ORGANICS UTILIZING AN AIR-STRIPPER WITH GAS PHASE CARBON ABSORPTION FROM THE AIR STREAM. POLISHING OF THE LIQUID STREAM UTILIZING LIQUID PHASE CARBON ABSORPTION CAN ALSO BE INCLUDED, AS NECESSARY. VOLATILE CONTAMINANTS ARE TRANSFERRED FROM THE GROUND WATER TO THE AIR, VIA CONTINUOUS CONTACT IN THE TOWER. THE GROUND WATER STREAM IS INTRODUCED AT THE TOP OF THE TOWER WHILE AIR IS BLOWN INTO THE BASE OF THE TOWER AND FLOWS UPWARD, CONTACTING WITH THE WATER.

AIR-STRIPPING IS AN EFFICIENT MEANS OF REMOVING VOLATILES FOR COMPOUNDS WITH HENRY'S LAW CONSTANTS GREATER THAN 0.001 (APPLIES TO ALL THE VOCS AT THE MEW SITE). THE AIR-STRIPPER OFF-GAS IS TREATED BY VAPOR PHASE CARBON ABSORPTION TO PREVENT RELEASE OF THE STRIPPED CONTAMINANTS TO THE ATMOSPHERE.

PRIOR TO THE INSTALLATION OF THE GROUND WATER REMEDIATION SYSTEM, ADDITIONAL INVESTIGATION OF THE HYDROGEOLOGIC REGIME IN THE VICINITY OF THE MEW SITE WILL BE PERFORMED. THE PURPOSE OF THIS INVESTIGATION WILL BE TO IDENTIFY THE VERTICAL EXTENT OF CONTAMINATION; CONFIRM THE PRESENCE OR ABSENCE OF A CONTINUOUS AQUICLUDE WITHIN THE UPPER 200-300 FEET OF THE BEDROCK; PERFORM PUMP TESTS TO DETERMINE THE FLOW RATES AND HYDRAULIC CONDUCTIVITY OF THE AQUIFER; CONFIRM THE FLOW DIRECTION OF THE AQUIFER; AND IDENTIFY OTHER DATA THAT WILL BE NECESSARY FOR THE DESIGN OF THE GROUND WATER REMEDIATION SYSTEM.

ELEMENTS REQUIRED FOR IMPLEMENTATION OF THE GROUND WATER REMEDY INCLUDE THE FOLLOWING:

THE AQUIFER WILL BE TESTED, EITHER BY PUMP OR SLUG TESTS, TO IDENTIFY FLOW RATES AND HYDRAULIC CONDUCTIVITY OF THE AQUIFER. THIS INFORMATION WILL BE NEEDED TO DESIGN THE EXTRACTION WELL NETWORK TO OPTIMIZE ITS REMOVAL EFFICIENCY. IN ADDITION, THE WATER EXTRACTED DURING THE PUMP TESTS WILL BE SAMPLED AND ANALYZED TO BETTER IDENTIFY THE CONTAMINANTS AND ASSOCIATED CONCENTRATIONS PRESENT IN THE GROUND WATER. DESIGN PARAMETERS AFFECTED BY THE RESULTS OF THIS TESTING INCLUDE: THE SIZE OF THE WELLS, PUMPS AND STORAGE TANKS; THE LENGTH OF PUMPING TIME; THE SIZE OF THE AIR STRIPPING TOWER; AND THE AMOUNT OF ACTIVATED CARBON NEEDED TO FILTER THE VAPOR PHASE.

GROUND WATER FROM THE SITE WILL BE USED IN A BENCH-SCALE AIR- STRIPPER TEST TO EVALUATE THE EFFECTIVENESS OF THE SYSTEM ON THE SITE CONTAMINANTS. THE INFORMATION GATHERED FROM THESE TESTS WILL BE USED TO ADJUST DESIGN PARAMETERS TO ACHIEVE OPTIMUM CONTAMINANT REDUCTION AND REMOVAL.

AFTER THE DATA FROM THESE TESTS ARE AVAILABLE, A CONCEPTUAL DESIGN OF THE EXTRACTION WELL NETWORK WILL BE PRODUCED. THIS CONCEPTUAL DESIGN WILL BE STUDIED AND REVIEWED TO IDENTIFY IF A MORE EFFICIENT OR COST-EFFECTIVE OPTION EXISTS. WHEN THIS PEER REVIEW IS COMPLETE, THE EXTRACTION WELL SYSTEM WILL BE DESIGNED. THIS DESIGN WILL INCLUDE WELL LOCATIONS, PUMP SIZES, PUMPING FREQUENCY, LOCATION AND SIZES OF CONNECTING PIPING, THE SIZE AND LOCATION OF THE STORAGE TANK AND THE LOCATION OF THE AIR-STRIPPER.

THE DATA GATHERED DURING THE AQUIFER TESTS AND THE TREATABILITY STUDY WILL BE USED TO DEVELOP THE SPECIFICATIONS FOR THE AIR-STRIPPER TO BE USED AT THE SITE. THESE SPECIFICATIONS WILL BE USED TO IDENTIFY THE VENDOR WITH THE MOST APPROPRIATE UNIT FOR THE SITE. AN AIR-STRIPPER, MODIFIED AS NECESSARY TO MEET SITE CRITERION, WILL THEN BE PURCHASED. THE PURCHASED AIR-STRIPPER SYSTEM WILL BE ASSEMBLED ONSITE. THE AIR-STRIPPER WILL HAVE PIPING FOR DISCHARGE OF THE PROCESSED WATER TO THE LOCAL POTW OR TO THE WETLAND AREA VIA A SURFACE WATER DISCHARGE.

THE EXTRACTION WELLS WILL BE STRATEGICALLY LOCATED TO INTERCEPT THE CONTAMINATED GROUND WATER. THE STORAGE TANK WILL BE INSTALLED WITH PIPING CONNECTED TO THE AIR-STRIPPER.

AFTER THE EXTRACTION WELLS AND APPURTENANT PIPING AND UTILITIES AND THE AIR-STRIPPER SYSTEM ARE INSTALLED THE ENTIRE SYSTEM WILL BE CONNECTED. PRESSURE TESTING OR VISUAL INSPECTION OF ALL CONNECTIONS WILL BE PERFORMED AS APPROPRIATE. THE SYSTEM THEN WILL BE STARTED-UP AND CLEANUP OF THE GROUND WATER INITIATED.

DISCHARGES FROM THE AIR-STRIPPER SYSTEM WILL BE MONITORED FREQUENTLY, BOTH THE VAPOR AND LIQUID PHASE. THE ANALYTICAL DATA FROM MONITORING WILL BE EVALUATED TO ENSURE THAT THE DISCHARGES ARE IN COMPLIANCE WITH THE REGULATIONS FOR SURFACE WATER AND AIR EMISSIONS. ADJUSTMENTS TO THE SYSTEM WILL BE MADE TO ENSURE THAT ALL APPROPRIATE REGULATIONS ARE COMPLIED WITH. THOSE PORTIONS OF THE SYSTEM WITH A FINITE OPERATIONAL LIFE, I.E., ACTIVATED CARBON FILTERS, WATER FILTER, WATER PUMPS, ETC., WILL BE REPLACED AS NECESSARY TO KEEP THE SYSTEM OPERATIONAL.

SAMPLES OF THE GROUND WATER WILL BE OBTAINED AND ANALYZED TO EVALUATE THE PERFORMANCE OF THE AIR-STRIPPER SYSTEM. THE EXTRACTION AND AIR-STRIPPING OF THE GROUND WATER WILL CONTINUE UNTIL RISK CRITERIA OR REGULATORY LIMITS ARE MET. AFTER REGULATORY LIMITS ARE MET AND MAINTAINED FOR A PERIOD NO LESS THAN ONE YEAR, THE SYSTEM WILL BE SHUT-DOWN. AFTER SHUT-DOWN THE GROUND WATER WILL BE MONITORED ON A QUARTERLY BASIS FOR A PERIOD OF AT LEAST TWO YEARS. IF DURING THIS TIME, THE CONTAMINANT CONCENTRATIONS DO NOT INCREASE ABOVE REGULATORY LIMITS, THE AIR-STRIPPING SYSTEM WILL BE DECOMMISSIONED AND THE EXTRACTION WELLS ABANDONED IN COMPLIANCE WITH THE REQUIREMENTS SET FORTH BY THE STATE OF MISSOURI.

PURSUANT TO CERCLA S121, ANY REMEDIAL ACTION THAT RESULTS IN ANY HAZARDOUS SUBSTANCES, POLLUTANTS, OR CONTAMINANTS REMAINING AT THE SITE SHALL BE REVIEWED NO LESS OFTEN THAN FIVE YEARS AFTER THE INITIATION OF SUCH REMEDIAL ACTION TO ENSURE THAT HUMAN HEALTH AND THE ENVIRONMENT ARE BEING PROTECTED BY THE REMEDIAL ACTION BEING IMPLEMENTED.

BECAUSE THE REMEDIAL ACTIONS FOR THE SITE WILL RESULT IN HAZARDOUS SUBSTANCES REMAINING IN THE ONSITE GROUND WATER AND WILL REQUIRE THAT INSTITUTIONAL CONTROLS BE PLACED ON THE SITE THE OVERALL SITE CONDITIONS WILL BE REVIEWED AT LEAST ONCE EVERY FIVE YEARS AFTER THE INITIATION OF THE REMEDIAL ACTION AT THE SITE. THIS REVIEW WILL BE CONSISTENT WITH THE CERCLA STANDARDS APPLICABLE FOR FIVE-YEAR SITE REVIEWS IN EFFECT AT THE TIME OF THE REVIEW. THE EXTENT AND NATURE OF THIS REVIEW PROGRAM WILL BE DEVELOPED DURING THE DESIGN PHASE OF THE SELECTED REMEDY, BUT WILL INCLUDE AT A MINIMUM, THOSE DATA COLLECTED DURING THE MONITORING PROGRAMS IDENTIFIED ABOVE FOR THE GROUND WATER AND THE ONSITE INCINERATOR.

#SD

11.0 STATUTORY DETERMINATIONS

THE REMEDIAL ACTIONS SELECTED FOR IMPLEMENTATION AT THE MISSOURI ELECTRIC WORKS SITE ARE CONSISTENT WITH CERCLA AND, TO THE EXTENT PRACTICABLE, THE NCP. THE SELECTED REMEDIES ARE PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT, ATTAIN ARARS, AND ARE COST-EFFECTIVE. THE

SELECTED REMEDIES ALSO SATISFY THE STATUTORY PREFERENCE FOR TREATMENT WHICH PERMANENTLY AND SIGNIFICANTLY REDUCE THE TOXICITY, MOBILITY, OR VOLUME OF HAZARDOUS SUBSTANCES AS A PRINCIPLE ELEMENT.

THE SELECTED REMEDIES FOR THE SITE WILL ADDRESS THE RELEASE OR THREAT OF RELEASE POSED BY THE CONTAMINATED SOILS, SEDIMENTS AND GROUND WATER. THE REMEDIES SELECTED ARE THEREBY PROTECTIVE.

THE SOIL AND SEDIMENT CLEANUP LEVELS TO BE ATTAINED THROUGH EXCAVATION AND ONSITE INCINERATION WILL REDUCE THE RISKS ASSOCIATED WITH THESE CONTAMINATED MATERIALS TO A LEVEL PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT. THESE CLEANUP LEVELS ADDRESS THE RISKS FROM DIRECT CONTACT, INHALATION AND INGESTION OF THE CONTAMINATED SOILS OR SEDIMENTS OR THE VAPORS ORIGINATING FROM THE CONTAMINATED SOILS AND SEDIMENTS.

THE EXTRACTION AND ONSITE TREATMENT OF THE GROUND WATER WILL COMPLY WITH THE CLEANUP LEVELS ESTABLISHED FOR THE SITE. THESE CLEANUP LEVELS ARE THE FEDERAL MCLS AND THE MISSOURI GROUND WATER CRITERIA.

THE SELECTED REMEDIES WILL MEET OR ATTAIN ALL APPLICABLE OR RELEVANT AND APPROPRIATE FEDERAL AND STATE REQUIREMENTS THAT APPLY TO THE SITE. FEDERAL AND STATE LAWS WHICH ARE APPLICABLE OR RELEVANT AND APPROPRIATE ARE IDENTIFIED IN APPENDIX A.

#DSC

12.0 DOCUMENTATION OF SIGNIFICANT CHANGES

THERE WERE NO SIGNIFICANT CHANGES MADE TO THE PROPOSED PLAN IN THIS RECORD OF DECISION.

#RS

THE RESPONSIVENESS SUMMARY:

1.0 OVERVIEW

IN THE PROPOSED PLAN RELEASED TO THE PUBLIC, THE ENVIRONMENTAL PROTECTION AGENCY (EPA), WITH MISSOURI DEPARTMENT OF NATURAL RESOURCE (MDNR) CONCURRENCE, MADE A PRELIMINARY SELECTION FOR THE PREFERRED ALTERNATIVE FOR REMEDIAL ACTION AT THE MISSOURI ELECTRIC WORKS SITE. EPA'S RECOMMENDED ALTERNATIVES ADDRESSED THE PCB-CONTAMINATED SOILS AND SEDIMENTS AND THE CONTAMINATED GROUND WATER AT THE SITE. THE PREFERRED ALTERNATIVE INVOLVED EXCAVATION AND ONSITE INCINERATION OF THE PCB-CONTAMINATED SOILS AND SEDIMENTS AND EXTRACTION AND TREATMENT, USING AN AIR-STRIPPER, OF THE CONTAMINATED GROUND WATER.

JUDGING FROM THE COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD, THE RESIDENTS OF CAPE GIRARDEAU GENERALLY ACCEPTED THE PREFERRED ALTERNATIVE AS PRESENTED. WITH THE EXCEPTION OF ONE COMMENT, OPPOSITION TO THE PREFERRED ALTERNATIVE FOR THE SOILS AND SEDIMENTS WAS NOT INDICATED.

2.0 BACKGROUND ON COMMUNITY INVOLVEMENT

EPA AND THE MISSOURI DEPARTMENT OF HEALTH HELD MEETINGS WITH ADJACENT PROPERTY OWNERS AND OTHER INTERESTED CITIZENS IN CAPE GIRARDEAU, MISSOURI ON JULY 11 AND 12, 1989. THE PURPOSE OF THESE MEETINGS WAS TO DISCUSS THE SITE CONDITIONS AND THE HEALTH RISKS THAT THE SITE REPRESENTED TO THE GENERAL PUBLIC. EPA STAFF PARTICIPATED IN TWO LOCAL CAPE GIRARDEAU, MISSOURI RADIO TALK SHOWS DURING JULY 1989; INTERESTED CITIZENS WERE ABLE TO "CALL-IN" AND ASK QUESTIONS OF THE EPA STAFF CONCERNING THE MISSOURI ELECTRIC WORKS SITE AND THE RELATED ACTIVITIES.

THE ADMINISTRATIVE RECORD WAS PLACED IN THE CAPE GIRARDEAU PUBLIC LIBRARY ON AUGUST 11, 1989. THE DOCUMENTS CONTAINED IN THE ADMINISTRATIVE RECORD IDENTIFIED THE NEED FOR A REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS). A PUBLIC MEETING WAS HELD IN CAPE GIRARDEAU ON SEPTEMBER 19, 1989 TO INFORM THE PUBLIC OF THE DETAILS OF THE ONGOING REMEDIAL INVESTIGATION AND TO IDENTIFY POSSIBLY REMEDIAL ALTERNATIVES THAT WOULD BE CONSIDERED DURING THE FEASIBILITY STUDY. A SECOND PUBLIC MEETING WAS HELD ON JUNE 11, 1990 TO INFORM THE PUBLIC OF THE REMEDIAL INVESTIGATION FINDINGS AND TO AGAIN IDENTIFY THE REMEDIAL ALTERNATIVES THAT WOULD BE CONSIDERED DURING THE FEASIBILITY STUDY. FACT SHEETS, IDENTIFYING SIGNIFICANT SITE ACTIVITIES, WERE ISSUED TO EVERYONE ON EPA'S MAILING LIST FOR THE SITE IN JUNE, AUGUST, AND NOVEMBER 1989 AND MARCH, MAY AND JULY 1990.

THE RI/FS AND PROPOSED PLAN FOR THE MISSOURI ELECTRIC WORKS SITE WERE RELEASED TO THE PUBLIC DURING AUGUST 1990. THESE THREE DOCUMENTS WERE MADE AVAILABLE TO THE PUBLIC IN THE ADMINISTRATIVE RECORD AND ITS ADDENDUM LOCATED IN THE EPA RECORD CENTER, REGION VII AND AT THE CAPE GIRARDEAU, MISSOURI PUBLIC LIBRARY. THE NOTICE OF AVAILABILITY FOR THESE THREE DOCUMENTS WAS PUBLISHED IN THE NEWS GUARDIAN AND THE SOUTHEAST MISSOURIAN ON AUGUST 19, 1990. A PUBLIC COMMENT PERIOD WAS HELD FROM AUGUST 19 TO SEPTEMBER 17, 1990. IN ADDITION, A PUBLIC HEARING WAS HELD ON AUGUST 30, 1990. AT THIS MEETING, REPRESENTATIVES FROM EPA, THE MISSOURI DEPARTMENT OF NATURAL RESOURCES, THE MISSOURI DEPARTMENT OF HEALTH AND THE AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY (ATSDR) WERE AVAILABLE TO ANSWER QUESTIONS ABOUT PROBLEMS AT THE SITE AND THE REMEDIAL ALTERNATIVES UNDER CONSIDERATION.

3.0 SUMMARY OF COMMENTS RECEIVED DURING THE PUBLIC COMMENT PERIOD

COMMENTS RAISED DURING THE PUBLIC COMMENT PERIOD ON THE DRAFT FEASIBILITY STUDY (FS) AND PROPOSED PLAN ARE SUMMARIZED BELOW. THE PUBLIC COMMENT PERIOD WAS HELD FROM AUGUST 19 TO SEPTEMBER 17, 1990.

3.1 COMMENTS FROM INTERESTED CITIZENS

COMMENT #1

RUTH HATHAWAY, CHAIRMAN OF THE LOCAL EMERGENCY PLANNING COMMITTEE, AND BRUCE HATHAWAY, ASSOCIATE PROFESSOR OF CHEMISTRY AT SOUTHEAST MISSOURI STATE UNIVERSITY, WROTE TO EXPRESS THEIR SUPPORT OF EPA'S PREFERRED ALTERNATIVE OF ONSITE INCINERATION. THEY INDICATED THAT THIS ALTERNATIVE WAS AN EFFICIENT AND EFFECTIVE WAY TO DISPOSE OF PCBS.

RESPONSE

AS INDICATED IN THE PROPOSED PLAN, IT IS EPA'S OPINION THAT ONSITE INCINERATION IS THE ALTERNATIVE THAT MEETS THRESHOLD CRITERIA AND PROVIDES THE BEST BALANCE BETWEEN THE "PRIMARY BALANCING CRITERIA" AS IDENTIFIED IN THE NCP.

COMMENT #2

MR. C. J. MORRILL, WHO OWNS THE PROPERTY ADJACENT TO THE MEW PROPERTY AND OPERATES A CONSTRUCTION BUSINESS FROM THAT PROPERTY, ASKED SEVERAL QUESTIONS CONCERNING SPECIFIC DETAILS OF THE ACTUAL REMEDIAL ACTION.

RESPONSE

THE PROPOSED PLAN INDICATES THAT IT IS ESTIMATED THAT THE ONSITE INCINERATION OF PCB-CONTAMINATED SOILS WILL TAKE ABOUT TWO YEARS; THE GROUND WATER EXTRACTION AND TREATMENT IS ANTICIPATED TO CONTINUE FOR APPROXIMATELY 15 YEARS. IT IS NOT POSSIBLE, AT THIS TIME, TO ANSWER THE QUESTIONS REGARDING THE SPECIFICS OF ACTUAL REMEDIAL ACTION ITEMS SINCE THE DESIGN HAS NOT BEEN INITIATED NOR THE CONTRACTOR SELECTED. THE ANSWERS WILL REMAIN UNKNOWN UNTIL THE DESIGN FOR THE REMEDIAL ACTION HAS BEEN COMPLETED AND WITH RESPECT TO GROUND WATER, UNTIL THE CLEANUP LEVELS ARE ACHIEVED. EPA WILL BE OVERSEEING AND MONITORING THE REMEDIAL ACTION EFFORTS WHILE THEY ARE PERFORMED.

COMMENT #3

MR. MORRILL ALSO ASKED SOME QUESTIONS REGARDING ONSITE INCINERATION. SPECIFICALLY, HE WANTED TO HAVE A DETAILED EXPLANATION OF WHAT INCINERATION INVOLVES; HOW IT WOULD BE COMPLETED; HOW THE MATERIALS WOULD BE HANDLED; HOW EMISSIONS WOULD BE HANDLED; WHEN WOULD THE "BURNING" TAKE PLACE; WHAT WOULD HAPPEN TO THE RESIDUES; WHAT TYPE OF BACKFILL MATERIAL WOULD BE USED; WOULD THE AREA BE REVEGETATED; AND CONCERNS ABOUT HIS EMPLOYEES' HEALTH AND SAFETY DURING REMEDIATION.

RESPONSE

THERE ARE FIVE BASIC COMPONENTS TO A ROTARY KILN INCINERATOR (WHICH IS THE MOST COMMON TYPE OF INCINERATOR AND MAY BE CHOSEN FOR THE REMEDIAL ACTION). THESE COMPONENTS ARE: 1) THE ROTARY KILN (PRIMARY COMBUSTION CHAMBER); 2) SECONDARY COMBUSTION CHAMBER; 3) HEAT RECOVERY BOILER; 4) AIR POLLUTION CONTROL TRAIN; AND 5) EFFLUENT NEUTRALIZATION CHAMBER. THE SOIL IS FED IN TO THE ROTARY KILN THAT IS MOUNTED ON AN INCLINE. TEMPERATURES RANGE FROM 1,200 TO 1,800 DEGREES FAHRENHEIT AND THE RESIDENCE TIME DEPENDS ON THE CONTAMINANTS BEING TREATED. TYPICAL FEED RATES FOR SOILS IS 1,300 TO 1,400 POUNDS PER HOUR. THE SOIL IS REMOVED AT THE LOWER END OF THE KILN AND THE VAPORS REMOVED FROM THE SOIL. THE VAPORS ARE THEN PROCESSED THROUGH THE SECONDARY CHAMBER AT TEMPERATURES OF 1500 TO 3000 DEGREES FAHRENHEIT, TO COMPLETE OXIDATION. AS THE EXHAUST GASES EXIT THE SECONDARY CHAMBER, THEY ARE DIRECTED THROUGH A POLLUTION CONTROL TRAIN WHICH MAY CONSIST OF A WATER QUENCH, A PACKED SCRUBBING TOWER OR AN INJECTION SCRUBBER SYSTEM. DETAILS OF WHAT IS ANTICIPATED FOR THE ONSITE INCINERATION SYSTEM AT THE MEW SITE ARE PRESENTED ON PAGES 47 THROUGH 51 OF THE DECISION SUMMARY AND GRAPHICALLY ON FIGURE 11.

CONCEPTUALLY, THERE ARE NO PLANS TO STOP THE ONSITE INCINERATION PROCESS ONCE IT BEGINS. THE SOILS WILL BE EXCAVATED, PROCESSED, INCINERATED, TESTED AND USED AS BACKFILL ON THE MEW

PROPERTY.

CONCEPTUAL PLANS WOULD BE TO STOCKPILE EXCAVATED CONTAMINATED SOILS ON THE MEW PROPERTY TO AWAIT INCINERATION. ONLY VERY SHORT HAUL DISTANCES ARE ANTICIPATED.

AS INDICATED ABOVE, EMISSIONS FROM THE INCINERATOR WOULD BE PROCESSED THROUGH A POLLUTION CONTROL TRAIN TO ENSURE THAT ANY RELEASES TO THE ATMOSPHERE ARE MINIMIZED AND ARE IN COMPLIANCE WITH THE STANDARDS SET BY THE CLEAN AIR ACT AND THE TOXIC SUBSTANCES CONTROL ACT. FREQUENT MONITORING OF THE EMISSIONS WILL BE PERFORMED. ANALYTICAL TESTING OF THE EXHAUST GASES WILL BE DONE FREQUENTLY.

THE ACTUAL HOURS DURING THE DAY THAT THE INCINERATOR WILL BE OPERATING CANNOT BE IDENTIFIED AT THIS TIME. IT IS A QUESTION THAT CAN BE BETTER ANSWERED AFTER REMEDIAL DESIGN IS COMPLETED AND THE REMEDIAL ACTION IS UNDERWAY.

THE SOIL "ASH" WHICH REMAINS AFTER INCINERATION WILL BE TESTED USING TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP) TEST METHODS. (A FACT SHEET ON THE FINAL TOXICITY RULE IS ATTACHED). THIS TESTING PROCEDURE WILL IDENTIFY IF THE ASH IS HAZARDOUS. IT IS ANTICIPATED THAT THE ASH WILL NOT BE HAZARDOUS, AND, THUS, IT WILL BE USED AS A BACKFILL MATERIAL ON THE MEW PROPERTY. A CLEAN SOIL CAP WILL BE PLACED OVER THE ASH.

SPECIFICS OF SITE RESTORATION ARE NOT AVAILABLE AND WILL NOT BE AVAILABLE UNTIL AFTER THE REMEDIAL DESIGN ARE COMPLETE. IT IS ANTICIPATED THAT THE EXCAVATED AREAS OUTSIDE THE MEW PROPERTY WILL BE BACKFILLED USING A VERIFIED NON-CONTAMINATED SOIL FROM A RELATIVELY LOCAL BORROW SOURCE. AFTER BACKFILLING OPERATIONS ARE COMPLETE, THE AREA WILL BE REVEGETATED.

COMPLIANCE WITH THE ARARS WILL MINIMIZE ANY RISK DURING THE REMEDIAL ACTION, AS DISCUSSED IN THE RECORD OF DECISION. RISKS TO MORRILL CONSTRUCTION EMPLOYEES, ON MORRILL PROPERTY, IS NOT ANTICIPATED TO BE SIGNIFICANTLY DIFFERENT DURING THE REMEDIAL ACTION THAN THEY ARE NOW. MORRILL EMPLOYEES SHOULD STAY AWAY FROM THE EXCAVATION AND BACKFILL OPERATIONS ON MORRILL PROPERTY UNTIL THEY ARE COMPLETE. MORRILL EMPLOYEES SHOULD ALSO STAY AWAY FROM THE INCINERATOR AND ASSOCIATED OPERATIONS. AFTER THE REMEDIAL ACTION, THE THREAT TO HUMAN HEALTH AND THE ENVIRONMENT POSED BY THE PCB-CONTAMINATION WILL BE ELIMINATED.

COMMENT #4

MR. BRIAN GARDNER, LEGAL REPRESENTATIVE OF HALL STREET ASSOCIATES WHICH OWNS PROPERTY ADJACENT TO MEW PROPERTY, EXPRESSED CONCERNS REGARDING THE SPECIFIC AREAS WHICH WOULD BE CLEANED DURING THE REMEDIAL ACTION. HIS CLIENT WAS CONCERNED SINCE EPA HAD NOTIFIED IT DURING 1987 THAT PCBS AT CONCENTRATIONS OF 88 PPM HAD BEEN DETECTED ON THE HALL STREET ASSOCIATION PROPERTY. MR. GARDNER WAS ALSO CONCERNED SINCE HIS CLIENT HAD NOT RECEIVED ANALYTICAL DATA FROM SAMPLES OBTAINED DURING THE REMEDIAL INVESTIGATION.

RESPONSE

THE 10 PPM ISOCONCENTRATION LINE INDICATED IN THE PROPOSED PLAN IS ONLY AN ESTIMATE OF THE EXTENT OF REMEDIAL ACTION FOR THE SOILS. ALL SURFACE SOILS CONTAMINATED WITH PCBS AT CONCENTRATIONS EXCEEDING 10 PPM WILL BE EXCAVATED AS PART OF THE SOIL REMEDIAL ACTION.

ANALYTICAL RESULTS FROM SAMPLES, IF ANY, COLLECTED FROM THE HALL STREET ASSOCIATION PROPERTY WILL BE FORWARDED TO MR. GARDNER, BY EPA.

3.2 COMMENTS FROM POTENTIALLY RESPONSIBLE PARTIES

COMMENT #1

DR. T. R. WEST, REPRESENTING 12 RURAL ELECTRIC COOPERATIVES FROM THE STATES OF ILLINOIS, INDIANA, OHIO, AND TENNESSEE, MADE THE FOLLOWING COMMENTS ON EPA'S PROPOSED PLAN:

A. DR. WEST CONTENDS THAT THE ONSITE INCINERATION OF THE PCB-CONTAMINATED SOILS WILL ELIMINATE THE SOURCE OF CONTAMINATION IN THE RAVINE AREA. NATURAL ATTENUATION BY THE CLAY SOIL AND CHEMICAL DISPERSION OF THE ORGANIC CONTAMINANTS WITH TIME AND DISTANCE WILL REDUCE CONTAMINANT CONCENTRATIONS IN THE GROUND WATER TO THE PROPOSED ACTION LEVELS.

B. DR. WEST STATES THAT THE VOLATILE ORGANICS CONTAMINATING THE GROUND WATER ARE INDUSTRIAL CLEANING SOLVENTS AND NOT CONSTITUENTS FROM TRANSFORMER OIL OR OIL FROM OTHER ELECTRICAL EQUIPMENT.

C. THE GROUP OF TWELVE RURAL ELECTRIC COOPERATIVES ASSERT THAT THE TRANSFORMERS SENT TO MEW BY THEM WERE SENT BEFORE THE TSCA REGULATIONS BECAME EFFECTIVE IN 1979. THEREFORE, THEY HAVE NO OBLIGATION TO CLEANUP THE SITE.

D. DR. WEST STATES THAT BASED ON THE INFORMATION GATHERED DURING THE REMEDIAL INVESTIGATION, THE WATER BEARING ZONE TESTED DOES NOT QUALIFY AS AN AQUIFER. IT IS NOT POSSIBLE, ACCORDING TO THIS COMMENTOR, FOR A SUSTAINING WELL TO BE DEVELOPED IN THIS ZONE. THEREFORE, THERE IS NO PUBLIC HEALTH OR ENVIRONMENTAL THREAT TO GROUND WATER, AND NO NEED TO COLLECT AND TREAT GROUND WATER FROM THIS WATER-BEARING ZONE.

RESPONSE

A. EPA CONCURS WITH THE FACT THAT ONSITE INCINERATION WILL ELIMINATE THE PCB CONTAMINATION AND ANY VOLATILE ORGANIC CONTAMINATION THAT IS PRESENT IN THE SOILS TO BE INCINERATED. HOWEVER, THE DEPTH TO THE GROUND WATER AT THE SITE IS ALMOST 40 FEET. IT IS NOT ANTICIPATED THAT SOILS WILL BE EXCAVATED AND INCINERATED TO THESE DEPTHS. FURTHERMORE, VOLATILE ORGANIC CONTAMINATION WAS FOUND IN THE SOILS ADJACENT TO THE MEW STRUCTURE AND IN THE GROUND WATER NORTHWEST OF THE RAVINE AREA. THIS INDICATES THAT THERE MAY BE MULTIPLE SOURCES OF VOLATILE ORGANICS WHICH ARE CONTAMINATING THE GROUND WATER. ONSITE INCINERATION OF THE PCBS WILL NOT NECESSARILY REMOVE THE VOLATILE ORGANIC COMPOUND SOURCES OF GROUND WATER CONTAMINATION. MONITORING OF THE GROUND WATER WILL NOT ACTIVELY REDUCE THE THREATS POSED BY THE CONTAMINANTS PRESENT.

B. THE QUESTION OF LIABILITY FOR THE CONTAMINATION AT THE SITE IS NOT PERTINENT TO THE REMEDY SELECTION AND THIS RECORD OF DECISION. ACCORDINGLY, THIS COMMENT WILL NOT BE ADDRESSED AT THIS TIME.

C. SEE RESPONSE TO #1 - B ABOVE.

D. MDNR HAS IDENTIFIED THE GROUND WATER MONITORED AT THE MEW SITE AS AN AQUIFER. THE INFORMATION IN THE POSSESSION OF MDNR INDICATES THAT THERE IS NOT A CONTINUOUS AQUICLUDE IN THE BEDROCK, IN THE AREA OF THE MEW SITE, FOR A DEPTH OF APPROXIMATELY 1,000 FEET. CONTAMINATION IN GROUND WATER MIGRATES BOTH VERTICALLY AND HORIZONTALLY, WHICH COULD IMPACT EXISTING OR FUTURE DRINKING WATER WELLS. THERE IS NO INFORMATION IN THE RECORD OR IN DR. WEST'S LETTER THAT REFUTES THE MDNR DATA. CONSTRUCTION OF DEEP EXPLORATORY BORINGS WITH SUBSEQUENT INSTALLATION OF MONITORING WELLS TO BE CONDUCTED IN THE HYDROGEOLOGICAL INVESTIGATION DURING THE REMEDIAL DESIGN WILL PROVIDE INFORMATION ABOUT THE PRESENCE OR ABSENCE OF AN AQUICLUDE IN THE BEDROCK IN THE VICINITY OF THE MEW SITE AS WELL AS PROVIDE DATA REGARDING THE VERTICAL EXTENT OF GROUND WATER CONTAMINATION. THEREFORE, EPA DISAGREES WITH THE STATEMENT "THEREFORE, THERE IS NO PUBLIC HEALTH OR ENVIRONMENTAL THREAT TO GROUNDWATER, AND NO NEED TO COLLECT AND TREAT GROUND WATER FROM THIS WATER-BEARING ZONE."

COMMENT #2

STUART HUNT, LEGAL COUNSEL FOR MISSOURI ELECTRIC WORKS, INC., SUBMITTED THE FOLLOWING COMMENTS REGARDING EPA'S PROPOSED PLAN:

A. MR. HUNT INDICATED THAT THE MOST GLARING DEFICIENCY OF THE PROPOSED PLAN WAS THAT IT RECOMMENDS A REMEDY FOR THE PCB-CONTAMINATED SOILS THAT IS NOT COST-EFFECTIVE WHEN OTHER TREATMENTS ARE AVAILABLE THAT ARE EQUALLY PROTECTIVE OF HUMAN HEALTH AND THE ENVIRONMENT.

B. MR. HUNT INDICATED THAT THE PROPOSED PLAN DID NOT ADDRESS THE AIR POLLUTION THAT WOULD BE EMITTED FROM THE INCINERATOR AND ITS POSSIBLE ADVERSE EFFECTS TO HUMAN HEALTH AND THE ENVIRONMENT AND INTERFERE WITH THE ONGOING BUSINESSES IN THE AREA OF THE MEW SITE.

C. MR. HUNT FURTHER STATES THAT ACCORDING TO EPA GUIDANCE CONCENTRATIONS OF PCBS AT INDUSTRIAL SITES BELOW 500 PARTS PER MILLION REPRESENT "LOW THREAT" AND COULD BE ADDRESSED WITH CONTAINMENT AND SITE SECURITY. MEW BELIEVES THAT INSTITUTIONAL CONTROLS, FENCING, ASPHALT CAPPING AND DEED RESTRICTIONS WOULD ADEQUATELY PROTECT HUMAN HEALTH AND THE ENVIRONMENT AT A FAR LOWER COST.

RESPONSE

A. FOR THE REASONS SET FORTH IN THE RECORD OF DECISION, THE BEST BALANCE BETWEEN THE PRIMARY BALANCING CRITERIA IDENTIFIED IN THE NCP, INCLUDING COST-EFFECTIVENESS, IS PROVIDED BY ONSITE INCINERATION. THE STABILIZATION/FIXATION ALTERNATIVE PROVIDED SOME REDUCTION IN THE MOBILITY OF THE PCB-CONTAMINATION, IT DID NOT REDUCE THE TOXICITY AND ACTUALLY INCREASES THE VOLUME OF PCB-CONTAMINATED MATERIALS. ITS LONG-TERM EFFECTIVENESS IS LESS CERTAIN AS A RESULT OF EROSION, POSSIBLE SEISMIC EVENTS AND WEATHER VARIATIONS THAT MAY THREATEN THE INTEGRITY OF THE MONOLITH. THE COSTS PRESENTED FOR SOLVENT EXTRACTION DO NOT INCLUDE THE CONSTRUCTION OF A WATER TREATMENT UNIT, WHICH COULD AMOUNT TO OVER $1 MILLION.

AGAIN, ONSITE INCINERATION PROVIDED THE BEST BALANCE OF TRADE-OFFS, PARTICULARLY WITH RESPECT TO LONG-TERM EFFECTIVENESS AND THE PERMANENT REDUCTION OF TOXICITY, MOBILITY AND VOLUME.

B. AIR POLLUTION FROM THE ONSITE INCINERATOR IS ADDRESSED IN THE RECORD OF DECISION. A POLLUTION CONTROL TRAIN WILL BE PART OF THE ONSITE INCINERATOR. THE EMISSIONS FROM THE INCINERATOR WILL BE MONITORED FREQUENTLY TO ENSURE PROPER OPERATION. IT IS UNLIKELY THAT IMPROPER OPERATION OF THE INCINERATOR WOULD OCCUR WITH THE AMOUNT OF OVERSIGHT AND MONITORING THAT WILL BE PERFORMED. ATTEMPTS WILL BE MADE TO MINIMIZE THE AMOUNT OF INTERFERENCE WITH THE BUSINESS ACTIVITIES OF ONGOING BUSINESSES, TO THE EXTENT PRACTICABLE. THE PRIMARY PURPOSE OF THE REMEDIAL ACTION IS TO CLEANUP THE SITE AND TO REMOVE THE THREAT TO HUMAN HEALTH AND THE ENVIRONMENT. IN ACCOMPLISHING THIS DIRECTIVE, SOME SHORT-TERM INTERFERENCE MAY OCCUR.

C. THE ARITHMETIC MEAN OF THE SAMPLING PERFORMED AT THE MEW SITE DURING THE REMEDIAL INVESTIGATION IS OVER 500 PARTS PER MILLION. AS SUCH THE CONTAMINATION AT THE MEW SITE DOES NOT REPRESENT "LOW THREAT" CONCENTRATIONS. CONSTRUCTION OF FENCES, WARNING SIGNS AND AN ASPHALT CAP OVER THE CONTAMINATED AREA WOULD NOT BE PROTECTIVE OF HUMAN HEALTH OR THE ENVIRONMENT NOR WOULD IT MET APPLICABLE OR RELEVANT AND APPROPRIATE REGULATIONS (ARARS) WHICH IS THE THRESHOLD CRITERIA THAT MUST BE MET ACCORDING TO THE NCP. THIS REMEDIAL ALTERNATIVE WAS ELIMINATED FROM FURTHER CONSIDERATION DURING THE COMPARATIVE ANALYSIS IN THE PROPOSED PLAN BECAUSE IT DID NOT MEET THRESHOLD CRITERIA.

COMMENT #3

MR. THOMAS SIEDHOFF, AS REPRESENTATIVE OF THE MEW'S PRP STEERING COMMITTEE, SUBMITTED SEVERAL COMMENTS ON THE PROPOSED PLAN. THESE COMMENTS ARE SUMMARIZED BELOW:

A. THE STEERING COMMITTEE BELIEVES THAT STABILIZATION OF PCB-CONTAMINATED SOILS SATISFIES THE STATUTORY REQUIREMENTS OF CERCLA S121 AND MEETS THE SELECTION CRITERIA OF THE NCP.

B. THE STEERING COMMITTEE STATES THAT THE ARITHMETIC MEAN CONCENTRATION OF THE PCB-CONTAMINATION WITHIN THE 10 PPM ISOCONCENTRATION LINE IS ROUGHLY 522 PPM; THE GEOMETRIC MEAN IS ABOUT 20 PPM WITHIN THIS AREA. THE BLENDED SOILS WILL HAVE AN AVERAGE CONCENTRATION OF LESS THAN 50 PPM WHICH WOULD "LOGICALLY BE CONSIDERED TO BE BELOW THE THRESHOLD OF TSCA INCINERATION LIMITS."

C. THE STEERING COMMITTEE BELIEVES THAT INCINERATION IS A VERY EXPENSIVE OPTION AND FEEL THAT STABILIZATION/FIXATION OF THE SOILS AND THE LONG-TERM MANAGEMENT CONTROLS FOR ONSITE DISPOSAL SHOULD BE MINIMAL AND SHOULD NOT BE VIEWED AS A SIGNIFICANT DISADVANTAGE.

D. THE STEERING COMMITTEE STATES THAT THE GROUND WATER IS CONTAMINATED WITH CHLORINATED SOLVENTS. NONE OF THE PRPS SENT CHLORINATED SOLVENTS TO MEW AND THEREFORE SHOULD NOT BE RESPONSIBLE FOR THE GROUND WATER CONTAMINATION. THEY FEEL THAT THE REMEDIAL ACTION CAN AND SHOULD BE DIVIDED INTO TWO OPERABLE UNITS; ONE FOR SOIL AND ONE FOR GROUND WATER CONTAMINATION. THEY INDICATE THAT EPA SHOULD SELECT AN APPROPRIATE GROUND WATER REMEDY.

E. THE STEERING COMMITTEE STATE THAT THE MDNR LEAKING UNDERGROUND STORAGE TANK GUIDELINES DEFINE AN AQUIFER AS A GROUND WATER UNIT HAVING A FLOW OF 5 GALLONS PER MINUTE (GPM) OR MORE AS A "USABLE" AQUIFER. THE HYDRAULIC DATA GENERATED DURING THE RI INDICATES THAT THE MONITORING WELLS PROVIDED WATER VOLUMES SUBSTANTIALLY LESS THAN 5 GPM (ABOUT 1 GPM). IT QUESTIONS WHETHER THE GROUND WATER CONTAMINATION POSES ANY FUTURE RISKS TO HUMAN HEALTH OR THE ENVIRONMENT.

F. WHILE THE STEERING COMMITTEE ADMITS THAT DATA GAPS EXIST REGARDING THE VERTICAL EXTENT OF THE GROUND WATER CONTAMINATION AND THE HYDRAULIC PARAMETERS BELOW A DEPTH OF 60 FEET, IT BELIEVES THAT REMEDIATION OF THE SOIL CONTAMINATION WILL LIKELY MITIGATE THE SOURCE OF THE GROUND WATER CONTAMINATION. THE EXISTING GROUND WATER CONTAMINATION SHOULD BE ALLOWED TO ATTENUATE NATURALLY AFTER THE SOILS HAVE BEEN REMEDIATED OR THE GROUND WATER REMEDY SHOULD BE SELECTED AFTER THE RESULTS OF A SUPPLEMENTAL HYDROGEOLOGIC ASSESSMENT OF THE SITE AND SURROUNDING AREA HAVE BEEN MADE.

G. THE STEERING COMMITTEE BELIEVES THAT IT WOULD BE PRUDENT FOR EPA TO DEFER THE FINAL SELECTION OF A GROUND WATER ALTERNATIVE UNTIL A MORE COMPLETE EVALUATION OF THE GROUND WATER REGIME HAS BEEN PERFORMED AND A MORE THOROUGH ASSESSMENT OF THE ACTUAL CURRENT AND POTENTIAL FUTURE RISKS POSED BY GROUND WATER ARE EVALUATED.

RESPONSE

A. FOR THE REASONS SET FORTH IN THE RECORD OF DECISION, THE BEST BALANCE BETWEEN THE PRIMARY BALANCING CRITERIA IDENTIFIED IN THE NCP, INCLUDING COST-EFFECTIVENESS, IS PROVIDED BY ONSITE INCINERATION. THE STABILIZATION/FIXATION ALTERNATIVE PROVIDED SOME REDUCTION IN THE MOBILITY OF THE PCB-CONTAMINATION, IT DID NOT REDUCE THE TOXICITY AND ACTUALLY INCREASES THE VOLUME OF PCB-CONTAMINATED MATERIALS. ITS LONG-TERM EFFECTIVENESS IS LESS CERTAIN AS A RESULT OF EROSION, POSSIBLE SEISMIC EVENTS AND WEATHER VARIATIONS THAT MAY THREATEN THE INTEGRITY OF THE MONOLITH. THE COSTS PRESENTED FOR SOLVENT EXTRACTION DO NOT INCLUDE THE CONSTRUCTION OF A WATER TREATMENT UNIT, WHICH COULD AMOUNT TO OVER $1 MILLION. AGAIN, ONSITE INCINERATION PROVIDED THE BEST BALANCE OF TRADE-OFFS, PARTICULARLY WITH RESPECT TO LONG-TERM EFFECTIVENESS AND THE PERMANENT REDUCTION OF TOXICITY, MOBILITY AND VOLUME.

B. EPA EXPRESSED ITS CONCERNS REGARDING THE APPARENTLY LOW VALUE OF THE ARITHMETIC AND GEOMETRIC MEANS FOR PCB-CONTAMINATION CONCENTRATION LEVELS IN ITS COMMENT LETTER ON THE REMEDIAL INVESTIGATION REPORT. THE CALCULATED ARITHMETIC AND GEOMETRIC MEAN IDENTIFIED IN THIS COMMENT REPRESENT ONLY DISCRETE SAMPLING POINTS, MOST OF WHICH WERE OBTAINED DURING RI SAMPLING. THE ANALYTICAL DATA FROM EPA COMPOSITE SAMPLES WERE NOT INCLUDED. IT IS EPA'S OPINION THAT THE ARITHMETIC AND GEOMETRIC MEANS PRESENTED BY THE STEERING COMMITTEE UNDERESTIMATE THE CONCENTRATIONS OF PCBS CONTAMINATING THE SOILS, PARTICULARLY ON THE MEW PROPERTY. THE PCB CONCENTRATIONS IN THE SOILS, IN EPA'S OUR EVALUATION OF THE DATA, JUSTIFY SELECTION OF THE ONSITE INCINERATION REMEDY.

THE ARITHMETIC MEAN OF THE SAMPLING PERFORMED AT THE MEW SITE DURING THE REMEDIAL INVESTIGATION IS OVER 500 PARTS PER MILLION. AS SUCH THE CONTAMINATION AT THE MEW SITE DOES NOT REPRESENT "LOW THREAT" CONCENTRATIONS.

C. THE STABILIZATION/FIXATION ALTERNATIVE RELIES ON ENCAPSULATION OF THE CONTAMINATION IN A STABILIZED MONOLITH. THE RELATIVE LOW LEACHABILITY OF THE ENCAPSULATED MATERIALS RELIES ON THE SIGNIFICANTLY REDUCED SURFACE AREA AVAILABLE TO THE LEACHING PROCESS. AS MENTIONED IN THE PROPOSED PLAN, SHRINKAGE CRACKS OR FRACTURES IN THE MONOLITH AS A RESULT OF SEISMIC ACTIVITY AS WELL AS WEATHERING FORCES WILL INCREASE THE SURFACE AREA SUSCEPTIBLE TO LEACHING. OVER TIME THESE WEATHERING FORCES COULD SIGNIFICANTLY REDUCE THE INTEGRITY OF THE STABILIZED MASS, THEREBY MAKING IT LESS EFFECTIVE AS A CONTAINMENT OR ENCAPSULATING MEDIUM. AS

EXPLAINED IN THE RECORD OF DECISION, EPA CONSIDERS ONSITE INCINERATION OF THE PCB-CONTAMINATED SOILS TO BE COST-EFFECTIVE.

D. THE QUESTION OF LIABILITY FOR THE CONTAMINATION AT THE SITE IS NOT PERTINENT TO THE REMEDY SELECTION AND THIS RECORD OF DECISION. ACCORDINGLY, THIS COMMENT WILL NOT BE ADDRESSED AT THIS TIME.

BASED ON THE DATA GATHERED DURING THE VARIOUS INVESTIGATIONS AT THE SITE AND THE INFORMATION IN THE POSSESSION OF MDNR REGARDING THE HYDROGEOLOGIC REGIME IN THE VICINITY OF THE SITE, IT WAS THE OPINION OF EPA THAT BOTH REMEDIES CAN AND THEREFORE SHOULD BE SELECTED AT THIS TIME. HOWEVER, PROVISION HAS BEEN MADE FOR ADDITIONAL INVESTIGATION AND MONITORING OF GROUND WATER AT THE SITE DURING THE REMEDIAL DESIGN PROCESS.

E. ACCORDING TO THE STATE OF MISSOURI, GEOLOGIC SURVEY, THERE IS NO CONFINING LAYER, SUCH AS A CONTINUOUS SHALE BED, IN THE VICINITY OF THE MEW SITE FOR A DEPTH OF 1,000 FEET. THIS MEANS THAT THERE IS NO BARRIER BETWEEN THE CONTAMINATION DETECTED IN THE UPPER 30+ FEET OF BEDROCK AND THE GROUND WATER BEING USED IN THE LOWER PORTIONS OF THE AQUIFER. THEREFORE, EPA AND MDNR BELIEVES THAT THE CONTAMINATION PRESENT IN THE UPPER PORTION OF THE AQUIFER DOES REPRESENT A RISK TO HUMAN HEALTH AND THE ENVIRONMENT.

F. EPA AGREES THAT ADDITIONAL INFORMATION ABOUT THE HYDROGEOLOGIC REGIME IN THE VICINITY OF THE SITE WOULD BE HELPFUL TO EFFECTIVELY DESIGN THE REMEDY. A PROVISION FOR ADDITIONAL INVESTIGATION INTO THE GROUND WATER CONDITIONS, I.E, HORIZONTAL AND VERTICAL EXTENT OF CONTAMINATION, DIRECTION OF GROUND WATER FLOW, DEPTH TO A CONFINING LAYER, ETC. HAS BEEN INCLUDED IN THE RECORD OF DECISION, IN THE SELECTED GROUND WATER REMEDY. THESE STUDIES WOULD BE PERFORMED PRIOR TO THE INITIATION OF GROUND WATER TREATMENT.

EPA CONCURS WITH THE FACT THAT ONSITE INCINERATION WILL ELIMINATE THE PCB CONTAMINATION AND ANY VOLATILE ORGANIC CONTAMINATION THAT IS PRESENT IN THE SOILS TO BE INCINERATED. HOWEVER, THE DEPTH TO THE GROUND WATER AT THE SITE IS ALMOST 40 FEET. THE VOLATILE ORGANIC COMPOUNDS DETECTED IN THE GROUND WATER ARE CLASSIFIED AS "SINKERS" ; WHICH MEANS THAT THESE CHEMICAL COMPOUNDS ARE HEAVIER THAN WATER AND TEND TO SINK TO A CONFINING LAYER AND FLOW ALONG IT WITH DISPERSION INTO THE WATER AS THEY SINK. THE DATA AT THE SITE INDICATES THAT THERE MAY BE MULTIPLE SOURCES OF GROUND WATER CONTAMINATION. THE ONSITE INCINERATION OF THE CONTAMINATED SOILS MAY NOT REMOVE ALL SOURCE AREAS AND THEREFORE SHOULD NOT BE CONSIDERED A "FIX" FOR THE GROUND WATER CONTAMINATION.

G. EPA DOES NOT AGREE THAT THE DECISION REGARDING THE GROUND WATER REMEDY SELECTION SHOULD BE DEFERRED. ENOUGH INFORMATION EXISTS FROM WHICH TO SELECT A GROUND WATER REMEDY. HOWEVER, EPA WILL CONSIDER ADDITIONAL DATA GATHERED IN THE HYDROGEOLOGICAL INVESTIGATION DURING THE REMEDIAL DESIGN PROCESS.

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TABLE 1 -- SUMMARY OF PCB EXPOSURE RISKS FOR CHILDREN MISSOURI ELECTRIC WORKS SITE

CURRENT USE -- HAZARD INDEX (HI)

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	2.474	0.00356
DERMAL	8.514	0.0123
INHALATION	0.000140	0.0000349
TOTAL	10.980140	0.0158949

RESIDENTIAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	91.5	0.132
DERMAL	315	0.454
INHALATION	0.0620	0.0155
TOTAL	406.5620	0.6015

FUTURE USE -- HAZARD INDEX

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	6.24	0.00898
DERMAL	10.4	0.015
INHALATION	0.000167	0.0000419
TOTAL	16.640167	0.0240219

RESIDENTIAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	189	0.272
DERMAL	315	0.272
INHALATION	0.0620	0.0155
TOTAL	504.0620	0.3329

TABLE 2 -- SUMMARY OF PCB EXPOSURE RISKS FOR ADULTS MISSOURI ELECTRIC WORKS SITE

CURRENT USE -- HAZARD INDEX

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	0.0548	0.0000791
DERMAL	3.084	0.00443
INHALATION	0.000131	0.0000326
TOTAL	3.134931	0.0045417

RESIDENTIAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	0.284	0.000410
DERMAL	16.0	0.0230
INHALATION	0.0580	0.0145
TOTAL	16.342	0.03791

OCCUPATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	0.365	0.000527
DERMAL	20.5	0.0295
INHALATION	0.0193	0.00483
TOTAL	20.8843	0.034857

TABLE 3 -- SUMMARY OF PCB EXPOSURE RISKS FOR ADULTS MISSOURI ELECTRIC WORKS SITE

FUTURE USE -- HAZARD INDEX

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	0.650	0.000938
DERMAL	3.764	0.00541
INHALATION	0.000157	0.0000392
TOTAL	4.410157	0.0063872

RESIDENTIAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	20.3	0.0293
DERMAL	114	0.164
INHALATION	0.0580	0.0145
TOTAL	134.358	0.2078

OCCUPATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	20.3	0.0293
DERMAL	114	0.164
INHALATION	0.0193	0.00483
TOTAL	134.3193	0.19813

TABLE 4 -- SUMMARY OF PCB EXPOSURE RISKS FOR CHILDREN MISSOURI ELECTRIC WORKS SITE

CURRENT USE -- INCREASED CANCER RISKS

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	1 X (10-3)	2 X (10-6)
DERMAL	4 X (10-3)	4 X (10-3)
INHALATION	6 X (10-8)	2 X (10-8)
TOTAL	5 X (10-3)	4 X (10-3)

RESIDENTIAL

INGESTION	1 X (10-2)	2 X (10-5)
DERMAL	4 X (10-2)	4 X (10-2)
INHALATION	3 X (10-5)	7 X (10-6)
TOTAL	5 X (10-2)	4 X (10-2)

FUTURE USE -- INCREASED CANCER RISKS

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	3 X (10-3)	4 X (10-6)
DERMAL	5 X (10-3)	7 X (10-6)
INHALATION	8 X (10-8)	2 X (10-8)
TOTAL	8 X (10-3)	1.1 X (10-5)

RESIDENTIAL

INGESTION	8 X (10-2)	1 X (10-4)
DERMAL	1 X (10-1)	2 X (10-4)
INHALATION	3 X (10-5)	7 X (10-6)
TOTAL	1.8 X (10-1)	3 X (10-4)

TABLE 5 -- SUMMARY OF PCB EXPOSURE RISKS FOR ADULTS MISSOURI ELECTRIC WORKS SITE

CURRENT USE -- INCREASED CANCER RISKS

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	3 X (10-5)	4 X (10-8)
DERMAL	1 X (10-3)	2 X (10-6)
INHALATION	6 X (10-8)	1 X (10-8)
TOTAL	1 X (10-3)	2 X (10-6)

RESIDENTIAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	1 X (10-4)	2 X (10-7)
DERMAL	7 X (10-3)	1 X (10-5)
INHALATION	3 X (10-5)	6 X (10-6)
TOTAL	7.1X10-3	1.6 X (10-5)

OCCUPATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	2 X (10-4)	2 X (10-7)
DERMAL	9 X (10-3)	1 X (10-5)
INHALATION	6 X (10-6)	2 X (10-6)
TOTAL	9 X (10-3)	1.2 X (10-5)

TABLE 6 -- SUMMARY OF PCB EXPOSURE RISKS FOR ADULTS MISSOURI ELECTRIC WORKS SITE

FUTURE USE -- INCREASED CANCER RISKS

RECREATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	3 X (10-4)	4 X (10-7)
DERMAL	2 X (10-3)	2 X (10-6)
INHALATION	7 X (10-8)	2 X (10-8)
TOTAL	2.3 X (10-3)	2.4 X (10-6)

RESIDENTIAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	9 X (10-3)	1 X (10-5)
DERMAL	5 X (10-2)	7 X (10-5)
INHALATION	3 X (10-5)	6 X (10-6)
TOTAL	5.9 X (10-2)	8.6 X (10-5)

OCCUPATIONAL

EXPOSURE POINT	WORST CASE	MOST PROBABLE CASE
INGESTION	6 X (10-3)	9 X (10-6)
DERMAL	4 X (10-2)	5 X (10-5)
INHALATION	6 X (10-6)	2 X (10-6)
TOTAL	4.6 X (10-2)	6.1 X (10-5)

TABLE 7 -- SUMMARY OF EXPOSURE RISKS FOR ADULTS INGESTION OF VOC-CONTAMINATED GROUND WATER MISSOURI ELECTRIC WORKS SITE

FUTURE USE -- HAZARD INDEX

RESIDENTIAL

CONTAMINANT	WORST CASE	MOST PROBABLE CASE
TRANS 1,2-DICHLOROETHENE	0.055	0.011
CHLOROBENZENE	0.240	0.0094
1,1-DICHLOROETHANE	0.0036	0. 0078
TRICHLOROETHENE	(1)	(1)
TETRACHLOROETHENE	0.024	0.0044
BENZENE	(1)	(1)
TOTAL	0.32261	0.0326

OCCUPATIONAL

CONTAMINANT	WORST CASE	MOST PROBABLE CASE
TRANS 1,2-DICHLOROETHENE	0.0275	0.0055
CHLOROBENZENE	0.120	0.0047
1,1-DICHLOROETHANE	0.0018	0.0039
TRICHLOROETHENE	(1)	(1)
TETRACHLOROETHENE	0.0120	0.0022
BENZENE	(1)	(1)
TOTAL	0.1613	0.01613

(1) THE HAZARD INDEX CANNOT BE CALCULATED SINCE AN ACCEPTABLE DOSE HAS NOT BEEN ESTABLISHED.

TABLE 8 -- SUMMARY OF EXPOSURE RISKS FOR ADULTS INGESTION OF VOC-CONTAMINATED GROUND WATER MISSOURI ELECTRIC WORKS SITE

FUTURE USE -- INCREASED CANCER RISK

RESIDENTIAL

CONTAMINANT	WORST CASE	MOST PROBABLE CASE
TRANS 1,2-DICHLOROETHENE	(1)	(1)
CHLOROBENZENE	(1)	(1)
1,1-DICHLOROETHANE	2 X (10-5)	4 X (10-6)
TRICHLOROETHENE	2 X (10-6)	4 X (10-7)
TETRACHLOROETHENE	7 X (10-6)	1 X (10-6)
BENZENE	2 X (10-6)	9 X (10-7)
TOTAL	3 X (10-5)	6 X (10-6)

OCCUPATIONAL

CONTAMINANT	WORST CASE	MOST PROBABLE CASE
TRANS 1,2-DICHLOROETHENE4	(1)	(1)
CHLOROBENZENE	(1)	(1)
1,1-DICHLOROETHANE	7 X (10-6)	1 X (10-6)
TRICHLOROETHENE	8 X (10-7)	1 X (10-7)
TETRACHLOROETHENE	3 X (10-6)	5 X (10-7)
BENZENE	7 X (10-7)	3 X (10-7)
TOTAL	1 X (10-5)	2 X (10-6)

(1) INCREMENTAL RISK CANNOT BE CALCULATED SINCE A CARCINOGENIC POTENCY FACTOR IS NOT ESTABLISHED.

TABLE 9 -- SUMMARY OF EXPOSURE RISKS FOR CHILDREN INGESTION OF VOC-CONTAMINATED GROUND WATER MISSOURI ELECTRIC WORKS SITE

FUTURE USE -- HAZARD INDEX

RESIDENTIAL

CONTAMINANT	WORST CASE	MOST PROBABLE CASE
TRANS 1,2-DICHLOROETHENE	0.175	0.0345
CHLOROBENZENE	0.750	0.0295
1,1-DICHLOROETHANE	0.011	0.0025
TRICHLOROETHENE	(1)	(1)
TETRACHLOROETHENE	0.076	0.0140
BENZENE	(1)	(1)
TOTAL	1.012	0.0805

FUTURE USE -- INCREASED CANCER RISK

RESIDENTIAL

CONTAMINANT	WORST CASE	MOST PROBABLE CASE
TRANS 1,2-DICHLOROETHENE	(2)	(2)
CHLOROBENZENE	(2)	(2)
1,1-DICHLOROETHANE	9 X (10-6)	2 X (10-6)
TRICHLOROETHENE	1 X (10-6)	2 X (10-7)
TETRACHLOROETHENE	3 X (10-6)	6 X (10-7)
BENZENE	6 X (10-6)	3 X (10-6)
TOTAL	2 X (10-5)	6 X (10-6)

(1) THE HAZARD INDEX CANNOT BE CALCULATED SINCE AN ACCEPTABLE DOSE HAS NOT BEEN ESTABLISHED.

(2) INCREMENTAL RISK CANNOT BE CALCULATED SINCE A CARCINOGENIC POTENCY FACTOR IS NOT ESTABLISHED.

B

APPENDIX B

TABLE B.1
POTENTIAL CHEMICAL SPECIFIC ARARS AND TBCS
MISSOURI ELECTRIC WORKS (MEW) SITE

Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Regulatory Requirement	Safe Drinking Water Act (SDWA)-Maximum Contaminant Levels (MCLs) (40 CFR § 141.11-141.14), Revised MCLS (40 CFR § 141.61-141.62) and non-zero Maximum Contaminant Level Goals (MCLGs) (40 CFR § 141,50-141.51)	Applicable	MCLs have been promulgated for a number of common organic and inorganic contaminants to regulate the concentration of contaminants in public drinking water supplys systems. MCLS are applicable for Site groundwater because groundwater in the Site vicinity is a potential drinking water supply.	MCLs are used to determine TCLs for groundwater.
	National Ambient Water Quality Criteria (NAWQC) (33 U.S.C. § 1314(a) and 42 U.S.C. § 9621(d)(2) and Water Quality Standards (40 CFR § 131.36(b) and 131.38)	Relevant and Appropriate	NAWQC and water qaulity standards are standards intended to protect human health and aquatic life from contamination in surface water.	Although the NAWQC are nonenforceable guidelines, they may be potentially relevant and appropriate for groundwater in the absence of promulgated MCLs or MCLGs. Water quality standards are relevant and appropriate in the case that groundwater at the Site has the potential to discharge to surface water or where the discharge alternative for treated groundwater is disposal to surface water.

MEW Site File
3DISC104346

TABLE B.1
POTENTIAL CHEMICAL SPECIFIC ARARS AND TBCS
MISSOURI ELECTRIC WORKS (MEW) SITE

Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
State Regulatory Requirements	Missouri Water Quality Standards (10 CSR 20-7.031)	Applicable	Identifies beneficail uses of waters of the state, criteria to protect those uses and defines the antidegradation policy.	Applicable to all waters of the state
	Public Drinking Water Program Maximum Volatile Organic Chemical Contaminant Levels and Monitoring Requirements (10 CSR 60-4.100)	Applicable	State MCLs have been promulgated for a number of common organic contaminants to regulate the concentration of contaminants in public drinking water supplys systems. The regulations are generally equivalent to the Federal SDWA MCLs. State MCLs are applicable for Site groundwater because groundwater in the Site vicinity is a potential drinking water supply.	State MCLs are employed to develop Site TCLs for groundwater where they are stricter than Federal standards.
	Cleanupup Levels for Missouri (CALM)-Appendix B (Tier 1 Soil and Groundwater Cleanup Stanadrds)	Relevant and Appropriate	Establishes conservatively-derived, risk based Groundwater Target Concentrations (GTARC) for remediation of voluntary cleanup sites in Missouri.	Although the GTARC are nonenforceable guidelines, they may be potentially relevant and appropriate for groundwater in the absence of promulgated MCLs or MCLGs.

TABLE B.1
POTENTIAL CHEMICAL SPECIFIC ARARS AND TBCS
MISSOURI ELECTRIC WORKS (MEW) SITE

Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Guidance	U.S Environmental Protection Agency (USEPA) Risk Reference Doses (RDs)	To Be Considered	RfDs are dose levels developed by USEPA for evaluating incremental human carcinogenic risk from exposure to carcinogens	RfDs are used to evaluate human health risks from exposure to non-carcinogenic Site contaminants.
	USEPA Human Health Assessment Cancer Slope Factors	To Be Considered	CSFs are developed by USEPA for evaluating incremental human carcinogenic risk from exposure to carcinogens	CSFs are used to evaluate cancer risk resulting from exposure to carcinogenic Site COCs.
	USEPA Health Advisories, Human Health Risk Assessment Guidance and Ecological Risk Assessment Guidance	To Be Considered	These guidance documents and advisories establish criteria and provide guidelines for evaluating human health and ecological risk at CERCLA sites.	These guidance documents and advisories are used to evaluate human health and ecological risk due to Site COCs.

TABLE B.2
POTENTIAL LOCATION SPECIFIC ARARS AND TBCS
MISSOURI ELECTRIC WORKS (MEW) SITE

Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Regulatory Requirement	Protection of Wetlands (Executive Order 11990), 40 CFR Part 6, App A (Policy on Implementing E.O. 11990)	Applicable	Requires federal agencies to minimize the destruction, loss, or degradation of wetlands; preserve and enhance the natural and beneficial value of wetlands; and avoid support of new construction in wetlands if a practiable alternative exists.	The U.S. Army Corps of Engineers has identified a jurisdictional wetland downgradient of the Site
	Floodplain Management (Executive Order 11988, 40 CFR 6.302(b) and 40 CFR Part 6, App A (Policy on Implementing E.O. 11988)	Applicable	Requires federal agencies to evaluate the potential effects of action they may take in floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain.	The potential effects on the the Cape La Croix will be considered during the development and evaluation of remedial alternatives. All practicable measures will be taken to limit adverse effects on floodplains.
	Resource Conservation and Recovery Act (RCRA) Floodplain Restriction for Hazardous Waste Facilities ($) CFR 264.18(b))	Applicable	A hazardous waste facility located in a 100-year floodplain must be designed, constructed, operated and maintained to prevent washout of any hazardous waste by a 100-year flood, unless the owner or operator can demonstrate that procedures are in effect that will cause the waste to be removed safely, before floodcan reach the facility	If remedial alternatives are developed, which include hazardous waste facilities in the floddplain at the Site, then the facilities need to comply with these requirements.

MEW Site File
3DISC104349

TABLE B.2
POTENTIAL LOCATION SPECIFIC ARARS AND TBCS
MISSOURI ELECTRIC WORKS (MEW) SITE

Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
State Regulatory Requirements	Protection of Lakes and Stream - Missouri Water Quality Standards (10 CSR 20-7.031)	Applicable	Promulgates rules to protect quality of lakes and streams. Beneficial uses of Cape La Croix Creek is designated as livestock & wildlife watering and protection of warnm water and aquatic life and human health-fish consumption.	Chemical specific ARARs are listed in Table B.1.

TABLE B.3
POTENTIAL ACTION SPECIFIC ARARS AND TBCS
MISSOURI ELECTRIC WORKS (MEW) SITE

Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Regulatory Requirement	National Pollutant Discharge Elimination Ssytem (NPDES) (40 CFR Part 122, 125)	Applicable	Requires permits for the discharge of pollutants from any point sources into waters of the United States. The Act defines a point source as any discernable, confined, or discrete conveyance from which pollutants are or may be discharged. Effluent limitations must protect beneficial uses of water.	Remedial alternatives which would discharge a pollutant into surface waters would enter into the NPDES regulatory framework. A permit is not required for on-site CERCLA response action, but the substantive requirements would apply.
	National Primary and Secondary Ambient Air Quality (40 CFR Part 50)	Applicable	Establishes Nation Ambient Air Quality Standards (NAAQS) for ambient air to protect public health and welfare.	Primary standard applicable for any alternative emmiting regulated pollutants.
	National Emission Standards for Hazardous Air Pollutants	Applicable	Sets National Emissions Standards for Hazardous Air Pollutants (NESHAP) for designated hazardous pollutants, including benzene.	Pollutants with standards are present at the Site. If air stripping is used standards may come into effect.
Federal Regulatory Requirement	Standards of Performance for New Stationary Sources (40 CFR Part 60)	Applicable	Sets new source performance standards (NSPs) for emissions from new and modified sources. The standards reflect the degree of emission reduction achieavable through demonstrated best technology, considering costs and a number of other factors.	If alternative involve discharge to POTW, it will be applicable.

TABLE B.3
POTENTIAL ACTION SPECIFIC ARARS AND TBCS
MISSOURI ELECTRIC WORKS (MEW) SITE

Authority	Requirement	Status	Requirement Synopsis	Consideration in the FS
Federal Regulatory Requirement	Standards Applicable to Transporters of Hazardous Waste (40 CFR Part 263)	Applicable	Establishes standrads which apply to persons transporting hazardous waste within the US if the transportation requires a manifest under 40 CFR Part 262.	If alternative involves off-site transportation of hazardous materials.

C

APPENDIX C

C VOLUME ESTIMATE CALCULATIONS

The volume of impacted water within the source areas has been calculated as the volume of water within the loess plus the volume of water within the fractures of the weathered limestone:

$$V = (A.b_{loess}.n_{loess}) + (A.b_{wl}.p_{32}.a_{eff})$$

where, V = volume of impacted water in source zone – ft^3 (m^3)

A= areal extent of source zone – ft^2 (m^2)

b_{loess} = saturated thickness of loess in source area – ft (m)

n_{loess} = porosity of loess (dimensionless)

b_{wl} = saturated thickness of weathered limestone – ft (m)

P_{32} = total fracture intensity (total surface area fractures per unit vol. of rock) – ft^2/ft^3 (m^2/m^3)

a_{eff} = effective fracture aperture – ft (m)

Two source areas have been modeled: Area 1- the source of chlorobenzenes and benzene in the south eastern corner of the site; and Area 2-the source of PCE and TCE in the centre of the site. The parameter values and estimated volumes are given in **Table C.1** below.

Table C.1: Volume Calculations

Parameter	Area 1	Area 2	Justification
Areal extent (A)	14,800 ft² (1375 m²)	13,993 ft2 (1300 m²)	Modeled areas in groundwater model
Saturated thickness of loess (b_{loess})	3.60 ft (1.1 m)	0.49 ft (0.15 m)	Average thickness from groundwater model results
Porosity of loess (n_{loess})	0.15	0.15	Best estimate from literature sources (referenced in groundwater model report)
Saturated thickness of weathered limestone (b_{wl})	45.9 ft (14 m)	42.6 ft (13 m)	Average thickness from groundwater model results
Total fracture intensity of weathered limestone (P_{32})	0.138 ft²/ft³ (0.45 m²/m³)	0.138 ft²/ft³ (0.45 m²/m³)	Total fracture intensity for both sets of vertical fractures within the limestone, estimated from fracture mapping of bedrock exposures
Effective fracture aperture in weathered limestone (a_{eff})	0.19 ft (0.06 m)	0.19 ft (0.06 m)	Estimated average fracture aperture from fracture mapping is 0.4m. Majority of fractures in weathered bedrock are infilled with loess, which has 15% porosity.
Volume of impacted groundwater in loess in source zone	7,992 ft³ (226 m³)	1,028 ft³ (29 m³)	Calculated
Volume of impacted groundwater in weathered limestone in source zone	17,811 ft³ (504 m³)	15,629 ft³ (442 m³)	Calculated
Total volume of impacted groundwater in source area (V)	25,803 ft³ (731 m³)	16,657 ft3 (472 m³)	Calculated

D

APPENDIX D

MEW Site File
3DISC104358

ALTERNATIVE FB-2

Inflation Rate	3.0%
Initial Discount Rate	5.0%
Discount Rate (Year 16 Through Year 30)	4.0%

Year	Yearly Cost	Yearly Cost With Inflation At Rate Shown	Net Present Value Of Yearly Inflated Cost At Bond Rate Shown	Cumulative Net Present Value
1	$180,497	$185,912	$177,059	$177,059
2	$155,719	$165,202	$149,843	$326,902
3	$155,719	$170,158	$146,989	$473,891
4	$75,074	$84,496	$69,515	$543,407
5	$99,852	$115,756	$90,698	$634,105
6	$75,074	$89,642	$66,892	$700,997
7	$75,074	$92,332	$65,618	$766,615
8	$75,074	$95,101	$64,368	$830,984
9	$75,074	$97,955	$63,142	$894,126
10	$99,852	$134,193	$82,383	$976,509
11	$75,074	$103,920	$60,760	$1,037,269
12	$75,074	$107,038	$59,603	$1,096,871
13	$75,074	$110,249	$58,467	$1,155,339
14	$75,074	$113,556	$57,354	$1,212,692
15	$99,852	$155,566	$74,830	$1,287,522
16	$75,074	$120,472	$64,321	$1,351,843
17	$75,074	$124,086	$63,702	$1,415,545
18	$75,074	$127,808	$63,090	$1,478,635
19	$75,074	$131,643	$62,483	$1,541,118
20	$99,852	$180,344	$82,307	$1,623,425
21	$75,074	$139,660	$61,287	$1,684,712
22	$75,074	$143,850	$60,698	$1,745,410
23	$75,074	$148,165	$60,114	$1,805,525
24	$75,074	$152,610	$59,536	$1,865,061
25	$99,852	$209,068	$78,425	$1,943,486
26	$75,074	$161,904	$58,397	$2,001,883
27	$75,074	$166,761	$57,835	$2,059,719
28	$75,074	$171,764	$57,279	$2,116,998
29	$75,074	$176,917	$56,729	$2,173,727
30	$99,852	$242,367	$74,726	**$2,248,453**
TOTALS	**$2,667,601**	**$4,218,494**	**$2,248,453**	

MEW Site File
3DISC104359

Project Name: MEW Superfund Site
Folder: MEW 041805
Project ID: MEW 041805 - FB2
Site Name: MEW 041805 - FB2
Site Type: None
Site ID: MEW 041805 - FB2
Phase Element Name: FB-2 Remedial Action
Phase Element Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Start Date: 41/2005

Location: ST LOUIS, MISSOURI

Media / Waste Type: Groundwater
Secondary Media / Waste Type: N/A
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: None
Markup Template: System Defaults

PHASE	TECHNOLOGY NAME	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
STUDY	Five-Year Review	$24,778				$24,778					$24,778			
MONITORING FOR MNA	Equipment, Materials & Analytical For Groundwater Monitoring	$30,290	$30,290	$30,290	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896
	Labor For Groundwater Monitoring	$125,429	$125,429	$125,429	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178
	TOTALS	$180,497	$155,719	$155,719	$75,074	$99,852	$75,074	$75,074	$75,074	$75,074	$99,852	$75,074	$75,074	$75,074

Notes:
1. 5-Year reviews will be conducted every 5 years starting in Year 1 (2005) of the Remedial Action.
2. Groundwater monitoring will be conducted quarterly for the first three years (2005 through 2007) and then annually after that for the remainder of the Remedial Action.
3. All costs were developed using RACER 2003 software (Remedial Action Cost Engineering & Requirements with 2003 Environmental Cost Handling Options & Solutions [ECHOS] cost database (published by the R.S. Means Company)).
4. Costs are presented as feasibility study level estimates (the period of system operation and final budget costs are subject to design and subsequent detailed cost review).

MEW Site File
3DISC104360

Year 14 2018	Year 15 2019	Year 16 2020	Year 17 2021	Year 18 2022	Year 19 2023	Year 20 2024	Year 21 2025	Year 22 2026	Year 23 2027	Year 24 2028	Year 25 2029	Year 26 2030	Year 27 2031	Year 28 2032	Year 29 2033	Year 30 2034	TOTALS	TECHNOLOGY NAME
	$24,778					$24,778					$24,778					$24,778	$173,446	Five-Year Review
$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$7,896	$304,062	Equipment, Materials & Analytical For Groundwater Monitoring
$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$67,178	$2,190,093	Labor For Groundwater Monitoring
$75,074	$99,852	$75,074	$75,074	$75,074	$75,074	$99,852	$75,074	$75,074	$75,074	$75,074	$99,852	$75,074	$75,074	$75,074	$75,074	$99,852	$2,667,601	TOTALS

ALTERNATIVE AL-2

Inflation Rate	3.0%
Initial Discount Rate	5.0%
Discount Rate (Year 16 Through Year 30)	4.0%

Year	Yearly Cost	Yearly Cost With Inflation At Rate Shown	Net Present Value Of Yearly Inflated Cost At Bond Rate Shown	Cumulative Net Present Value
1	$122,102	$125,765	$119,776	$119,776
2	$97,324	$103,251	$93,652	$213,428
3	$97,324	$106,349	$91,868	$305,296
4	$46,922	$52,811	$43,448	$348,744
5	$71,700	$83,120	$65,127	$413,870
6	$46,922	$56,027	$41,808	$455,679
7	$46,922	$57,708	$41,012	$496,691
8	$46,922	$59,439	$40,231	$536,922
9	$46,922	$61,223	$39,465	$576,386
10	$71,700	$96,359	$59,156	$635,542
11	$46,922	$64,951	$37,976	$673,518
12	$46,922	$66,900	$37,252	$710,770
13	$46,922	$68,907	$36,543	$747,313
14	$46,922	$70,974	$35,847	$783,159
15	$71,700	$111,706	$53,733	$836,892
16	$46,922	$75,296	$40,201	$877,093
17	$46,922	$77,555	$39,815	$916,908
18	$46,922	$79,882	$39,432	$956,339
19	$46,922	$82,278	$39,053	$995,392
20	$71,700	$129,498	$59,101	$1,054,493
21	$46,922	$87,289	$38,305	$1,092,799
22	$46,922	$89,907	$37,937	$1,130,736
23	$46,922	$92,605	$37,572	$1,168,308
24	$46,922	$95,383	$37,211	$1,205,519
25	$71,700	$150,124	$56,314	$1,261,832
26	$46,922	$101,192	$36,499	$1,298,331
27	$46,922	$104,227	$36,148	$1,334,479
28	$46,922	$107,354	$35,800	$1,370,279
29	$46,922	$110,575	$35,456	$1,405,735
30	$71,700	$174,035	$53,658	**$1,459,393**
TOTALS	**$1,732,312**	**$2,742,688**	**$1,459,393**	

MEW Site File
3DISC104362

Project Name: MEW Superfund Site
Folder: MEW 041805
Project ID: MEW 041005 - AL2
Site Name: MEW 041805 - AL2
Site Type: None
Site ID: MEW 041805 - AL2
Phase Element Name: AL-2 Remedial Action
Phase Element Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Start Date: 41/2005

Location: ST LOUIS, MISSOURI

Media / Waste Type: Groundwater
Secondary Media / Waste Type: N/A
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: None
Markup Template: System Defaults

PHASE	TECHNOLOGY NAME	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
STUDY	Five-Year Review	$24,778				$24,778					$24,778			
MONITORING FOR MNA	Equipment, Materials & Analytical For Groundwater Monitoring	$18,931	$18,931	$18,931	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935
	Labor For Groundwater Monitoring	$78,393	$78,393	$78,393	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987
	TOTALS	$122,102	$97,324	$97,324	$46,922	$71,700	$46,922	$46,922	$46,922	$46,922	$71,700	$46,922	$46,922	$46,922

Notes:
1. 5-Year reviews will be conducted every 5 years starting in Year 1 (2005) of the Remedial Action.
2. Groundwater monitoring will be conducted quarterly for the first three years (2005 through 2007) and then annually after that for the remainder of the Remedial Action.
3. All costs were developed using RACER 2003 software (Remedial Action Cost Engineering & Requirements with 2003 Environmental Cost Handling Options & Solutions [ECHOS] cost database (published by the R.S. Means Company)).
4. Costs are presented as feasibility study level estimates (the period of system operation and final budget costs are subject to design and subsequent detailed cost review).

Year 14 2018	Year 15 2019	Year 16 2020	Year 17 2021	Year 18 2022	Year 19 2023	Year 20 2024	Year 21 2025	Year 22 2026	Year 23 2027	Year 24 2028	Year 25 2029	Year 26 2030	Year 27 2031	Year 28 2032	Year 29 2033	Year 30 2034	TOTALS	TECHNOLOGY NAME
	$24,778					$24,778					$24,778					$24,778	$173,446	Five-Year Review
$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$4,935	$190,038	Equipment, Materials & Analytical For Groundwater Monitoring
$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$41,987	$1,368,828	Labor For Groundwater Monitoring
$46,922	$71,700	$46,922	$46,922	$46,922	$46,922	$71,700	$46,922	$46,922	$46,922	$46,922	$71,700	$46,922	$46,922	$46,922	$46,922	$71,700	$1,732,312	TOTALS

MEW Site File
3DISC104364

ALTERNATIVE AL-3

Inflation Rate	3.0%
Initial Discount Rate	5.0%
Discount Rate (Year 16 Through Year 30)	4.0%

Year	Yearly Cost	Yearly Cost With Inflation At Rate Shown	Net Present Value Of Yearly Inflated Cost At Bond Rate Shown	Cumulative Net Present Value
1	$952,800	$981,384	$934,651	$934,651
2	$412,165	$437,266	$396,613	$1,331,264
3	$405,837	$443,469	$383,085	$1,714,350
4	$272,259	$306,430	$252,101	$1,966,450
5	$271,083	$314,259	$246,231	$2,212,681
6	$295,174	$352,453	$263,006	$2,475,687
7	$269,944	$331,997	$235,944	$2,711,631
8	$269,624	$341,552	$231,176	$2,942,807
9	$269,385	$351,486	$226,571	$3,169,378
10	$269,200	$361,782	$222,103	$3,391,481
11	$293,830	$406,729	$237,806	$3,629,287
12	$268,932	$383,433	$213,510	$3,842,797
13	$268,831	$394,787	$209,364	$4,052,161
14	$268,747	$406,504	$205,312	$4,257,473
15	$268,674	$418,585	$201,347	$4,458,820
16	$293,389	$470,803	$251,366	$4,710,185
17	$268,556	$443,882	$227,877	$4,938,063
18	$268,508	$457,117	$225,646	$5,163,708
19	$268,465	$470,755	$223,440	$5,387,149
20	$268,427	$484,809	$221,261	$5,608,409
21	$934,903	$1,739,195	$763,217	$6,371,626
22	$268,361	$514,207	$216,973	$6,588,599
23	$268,332	$529,576	$214,863	$6,803,462
24	$268,306	$545,411	$212,776	$7,016,239
25	$268,283	$561,725	$210,712	$7,226,951
26	$293,039	$631,965	$227,943	$7,454,894
27	$268,241	$595,841	$206,647	$7,661,542
28	$268,222	$613,673	$204,646	$7,866,188
29	$268,205	$632,043	$202,665	$8,068,853
30	$292,967	$711,108	$219,248	$8,288,101
TOTALS	$9,822,689	$15,634,228	$8,288,101	

MEW Site File
3DISC104365

Project Name: MEW Superfund Site
Folder: MEW Revised 072804
Project ID: MEW Superfund Site
Site Name: MEW Superfund Site - AL-3
Site Type: None
Site ID: MEW Superfund Site - AL-3
Phase Element Name: AL-3 Remedial Action
Phase Element Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: Ex Situ
Start Date: 1/1/2005

Location: ST LOUIS, MISSOURI

Media / Waste Type: Groundwater
Secondary Media / Waste Type: N/A
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: None
Markup Template: System Defaults

PHASE	TECHNOLOGY NAME	Year 1 2005	Year 2 2006	Year 3 2007	Year 4 2008	Year 5 2009	Year 6 2010	Year 7 2011	Year 8 2012	Year 9 2013	Year 10 2014	Year 11 2015	Year 12 2016	Year 13 2017
STUDY	Five-Year Review	$24,778					$24,778					$24,778		
DESIGN	Design	$51,403												
CONSTRUCTION (CAPITAL COST)	Groundwater Extraction Wells	$151,357												
	Extraction Well Trenching & Piping	$10,346												
	Carbon Adsorption (Liquid) System	$66,186												
	Discharge To POTW Connection	$21,523												
	Overhead Electrical Distribution System	$23,788												
	Perimeter Fencing	$3,456												
	Residual Waste Management	$2,626												
	Professional Labor Management	$154,807												
MONITORING	Equipment, Materials & Analytical For Groundwater Monitoring	$49,221	$49,221	$49,221	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831
	Labor For Groundwater Monitoring	$203,822	$203,822	$203,822	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165
TREATMENT SYSTEM OPERATION & MAINTENANCE (O&M)	Miscellaneous Support Costs	$45,580	$20,586	$20,586	$20,586	$20,586	$20,586	$20,586	$20,586	$20,586	$20,586	$20,586	$20,586	$20,586
	Groundwater Extraction Wells	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033
	Carbon Adsorption (Liquid) System	$39,814	$34,641	$28,313	$25,782	$24,606	$23,919	$23,467	$23,147	$22,908	$22,723	$22,575	$22,455	$22,354
	Discharge to POTW Connection	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862
	TOTALS	$952,600	$412,165	$405,837	$272,259	$271,083	$295,174	$269,944	$269,624	$269,385	$269,200	$293,830	$268,932	$268,831

Notes:
1. 5-Year reviews will be conducted every 5 years starting in Year 1 (2005) of the Remedial Action.
2. The entire treatment system including groundwater extraction wells will be re-built after 20 years of operation (re-build to occur in Year 21).
3. Groundwater monitoring will be conducted quarterly for the first three years (2005 through 2007) and then annually after that for the remainder of the Remedial Action.
4. Treatment system O&M includes items for replacing system components on an annual basis, but no major system re-builds until after Year 20.
5. Discharge to the POTW includes a disposal cost of $3.14 per 1,000 gallons.
6. All costs were developed using RACER 2003 software (Remedial Action Cost Engineering & Requirements with 2003 Environmental Cost Handling Options & Solutions [ECHOS] cost database (published by the R.S. Means Company)).
7. Costs are presented as feasibility study level estimates (the period of system operation and final budget costs are subject to design and subsequent detailed cost review).

MEW Site File
3DISC104366

Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	TOTALS	TECHNOLOGY NAME
2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034		
		$24,778					$24,778					$24,778				$24,778	$173,446	Five-Year Review
							$51,403										$102,806	Design
							$151,357										$302,714	Groundwater Extraction Wells
							$10,346										$20,692	Extraction Well Trenching & Piping
							$64,186										$132,372	Carbon Adsorption (Liquid) System
							$21,523										$43,046	Discharge To POTW Connection
							$23,788										$47,576	Overhead Electrical Distribution System
							$3,456										$6,912	Perimeter Fencing
							$2,826										$5,652	Residual Waste Management
							$154,807										$309,614	Professional Labor Management
$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$49,221	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$12,831	$530,490	Equipment, Materials & Analytical For Groundwater Monitoring
$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$203,822	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$3,653,578	Labor For Groundwater Monitoring
$20,584	$20,586	$20,584	$20,586	$20,586	$20,586	$20,584	$45,580	$20,584	$20,586	$20,586	$20,586	$20,584	$20,586	$20,586	$20,586	$20,586	$667,568	Miscellaneous Support Costs
$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$12,033	$360,990	Groundwater Extraction Wells
$22,270	$22,197	$22,134	$22,079	$22,031	$21,988	$21,950	$21,915	$21,884	$21,855	$21,829	$21,806	$21,784	$21,764	$21,745	$21,728	$21,712	$709,375	Carbon Adsorption (Liquid) System
$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$91,862	$2,755,860	Discharge to POTW Connection
$268,747	$268,674	$293,389	$268,556	$268,500	$268,465	$268,427	$934,903	$268,361	$268,332	$268,306	$268,283	$293,039	$268,241	$268,222	$268,205	$272,967	$9,822,689	TOTALS

MEW Site File
3DISC104367

ALTERNATIVE AL-4

Inflation Rate	3.0%
Initial Discount Rate	5.0%
Discount Rate (Year 16 Through Year 30)	4.0%

Year	Yearly Cost	Yearly Cost With Inflation At Rate Shown	Net Present Value Of Yearly Inflated Cost At Bond Rate Shown	Cumulative Net Present Value
1	$611,272	$629,610	$599,629	$599,629
2	$327,174	$347,099	$314,829	$914,458
3	$327,174	$357,512	$308,832	$1,223,290
4	$121,995	$137,306	$112,962	$1,336,252
5	$220,904	$256,088	$200,652	$1,536,904
6	$121,995	$145,668	$108,700	$1,645,604
7	$196,126	$241,210	$171,424	$1,817,028
8	$121,995	$154,540	$104,598	$1,921,626
9	$196,126	$255,900	$164,955	$2,086,582
10	$146,773	$197,251	$121,095	$2,207,676
11	$196,126	$271,484	$158,731	$2,366,408
12	$121,995	$173,936	$96,854	$2,463,262
13	$196,126	$288,018	$152,742	$2,616,003
14	$121,995	$184,528	$93,199	$2,709,203
15	$220,904	$344,161	$165,547	$2,874,750
16	$121,995	$195,766	$104,521	$2,979,271
17	$196,126	$324,166	$166,418	$3,145,690
18	$121,995	$207,688	$102,521	$3,248,211
19	$196,126	$343,908	$163,233	$3,411,444
20	$146,773	$265,088	$120,983	$3,532,427
21	$196,126	$364,852	$160,109	$3,692,536
22	$121,995	$233,755	$98,634	$3,791,170
23	$196,126	$387,072	$157,045	$3,948,216
24	$121,995	$247,991	$96,747	$4,044,962
25	$220,904	$462,524	$173,500	$4,218,463
26	$121,995	$263,093	$94,895	$4,313,357
27	$196,126	$435,653	$151,092	$4,464,449
28	$121,995	$279,116	$93,079	$4,557,528
29	$196,126	$462,184	$148,200	$4,705,728
30	$146,773	$356,257	$109,841	**$4,815,568**
TOTALS	**$5,671,856**	**$8,813,425**	**$4,815,568**	

MEW Site File
3DISC104368

Project Name: MEW Superfund Site
Folder: MEW 041805
Project ID: MEW 041805 - AL4
Site Name: MEW 041805 - AL4
Site Type: None
Site ID: MEW 041805 - AL4
Phase Element Name: AL-4 Remedial Action
Phase Element Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Start Date: 4/1/2005

Location: ST LOUIS, MISSOURI

Media / Waste Type: Groundwater
Secondary Media / Waste Type: N/A
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: None
Markup Template: System Defaults

PHASE	TECHNOLOGY NAME	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
STUDY	Five-Year Review	$24,778				$24,778					$24,778				
DESIGN	Design	$20,400													
CONSTRUCTION (CAPITAL COST)	In Situ Biodegradation (Saturated Zone)	$144,942													
	Residual Waste Management	$2,129													
	Professional Labor Management	$91,850													
MONITORING	Equipment, Materials & Analytical For Groundwater Monitoring	$49,221	$49,221	$49,221	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830
	Labor For Groundwater Monitoring	$203,822	$203,822	$203,822	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165
HRC INJECTION	HRC Injection	$74,131	$74,131	$74,131		$74,131		$74,131		$74,131		$74,131		$74,131	
	TOTALS	$411,273	$327,174	$327,174	$121,995	$220,904	$121,995	$196,126	$121,995	$196,126	$146,773	$196,126	$121,995	$196,126	$121,995

Notes:

1. 5-Year reviews will be conducted every 5 years starting in Year 0 (2005) of the Remedial Action.
2. Groundwater monitoring will be conducted quarterly for duration of the Remedial Action.
3. All costs were developed using RACER 2003 software (Remedial Action Cost Engineering & Requirements with 2003 Environmental Cost Handling Options & Solutions (ECHOS) cost database (published by the R.S. Means Company)).
4. HRC injection will occur annually for the duration of the Remedial Action. HRC injection will occur in the five (5) new injection wells installed as part of this Remedial Action under the Construction (Capital Cost) task.
5. Costs are presented as feasibility study level estimates (the period of system operation and final budget costs are subject to design and subsequent detailed cost review).

MEW Site File
3DISC104369

Year 15 2019	Year 16 2020	Year 17 2021	Year 18 2022	Year 19 2023	Year 20 2024	Year 21 2025	Year 22 2026	Year 23 2027	Year 24 2028	Year 25 2029	Year 26 2030	Year 27 2031	Year 28 2032	Year 29 2033	Year 30 2034	TOTALS	TECHNOLOGY NAME
$24,778					$24,778					$24,778					$24,778	$173,446	Five-Year Review
																$20,400	Design
																$144,942	In Situ Biodegradation (Saturated Zone)
																$2,129	Residual Waste Management
																$91,850	Professional Labor Management
$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$12,830	$494,073	Equipment, Materials & Analytical For Groundwater Monitoring
$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$109,165	$3,558,921	Labor For Groundwater Monitoring
$74,131		$74,131		$74,131		$74,131		$74,131		$74,131		$74,131		$74,131		$1,186,096	HRC Injection
$220,904	$121,995	$196,126	$121,995	$196,126	$146,773	$196,126	$121,995	$196,126	$121,995	$220,904	$121,995	$196,126	$121,995	$196,126	$146,773	$5,471,854	TOTALS

ALTERNATIVE AL-5

Inflation Rate	3.0%
Initial Discount Rate	5.0%
Discount Rate (Year 16 Through Year 30)	4.0%

Year	Yearly Cost	Yearly Cost With Inflation At Rate Shown	Net Present Value Of Yearly Inflated Cost At Bond Rate Shown	Cumulative Net Present Value
1	$303,125	$312,219	$297,351	$297,351
2	$278,347	$295,298	$267,844	$565,195
3	$278,347	$304,157	$262,742	$827,938
4	$134,196	$151,039	$124,260	$952,198
5	$158,974	$184,294	$144,400	$1,096,597
6	$134,196	$160,237	$119,571	$1,216,169
7	$134,196	$165,044	$117,294	$1,333,463
8	$134,196	$169,995	$115,060	$1,448,522
9	$134,196	$175,095	$112,868	$1,561,390
10	$158,974	$213,648	$131,161	$1,692,551
11	$134,196	$185,759	$108,609	$1,801,161
12	$134,196	$191,331	$106,540	$1,907,701
13	$134,196	$197,071	$104,511	$2,012,212
14	$134,196	$202,983	$102,520	$2,114,733
15	$158,974	$247,676	$119,137	$2,233,869
16	$134,196	$215,345	$114,975	$2,348,844
17	$134,196	$221,806	$113,869	$2,462,713
18	$134,196	$228,460	$112,774	$2,575,487
19	$134,196	$235,313	$111,690	$2,687,177
20	$158,974	$287,125	$131,040	$2,818,217
21	$134,196	$249,644	$109,552	$2,927,769
22	$134,196	$257,133	$108,499	$3,036,268
23	$134,196	$264,847	$107,456	$3,143,723
24	$134,196	$272,793	$106,422	$3,250,146
25	$158,974	$332,856	$124,860	$3,375,006
26	$134,196	$289,406	$104,386	$3,479,391
27	$134,196	$298,088	$103,382	$3,582,773
28	$134,196	$307,031	$102,388	$3,685,161
29	$134,196	$316,242	$101,403	$3,786,564
30	$158,974	$385,872	$118,971	$3,905,536
TOTALS	$4,631,779	$7,317,809	$3,905,536	

MEW Site File
3DISC104371

Project Name: MEW Superfund Site
Folder: MEW 041805
Project ID: MEW 041805 - AL5
Site Name: MEW 041805 - AL5
Site Type: None
Site ID: MEW 041805 - AL5
Phase Element Name: AL-5 Remedial Action
Phase Element Type: Remedial Action
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Approach: In Situ
Start Date: 4/1/2005

Location: ST LOUIS, MISSOURI

Media / Waste Type: Groundwater
Secondary Media / Waste Type: N/A
Contaminant: Volatile Organic Compounds (VOCs)
Secondary Contaminant: None
Markup Template: System Defaults

PHASE	TECHNOLOGY NAME	Year 1 2005	Year 2 2006	Year 3 2007	Year 4 2008	Year 5 2009	Year 6 2010	Year 7 2011	Year 8 2012	Year 9 2013	Year 10 2014	Year 11 2015	Year 12 2016	Year 13 2017
STUDY	Five-Year Review	$24,778				$24,778					$24,778			
MONITORING FOR MNA	Equipment, Materials & Analytical For Groundwater Monitoring	$54,143	$54,143	$54,143	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114
	Labor For Groundwater Monitoring	$224,204	$224,204	$224,204	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082
	TOTALS	$303,125	$278,347	$278,347	$134,196	$158,974	$134,196	$134,196	$134,196	$134,196	$158,974	$134,196	$134,196	$134,196

Notes:
1. 5-Year reviews will be conducted every 5 years starting in Year 1 (2005) of the Remedial Action.
2. Groundwater monitoring will be conducted quarterly for the first three years (2005 through 2007) and then annually after that for the remainder of the Remedial Action.
3. All costs were developed using RACER 2003 software (Remedial Action Cost Engineering & Requirements with 2003 Environmental Cost Handling Options & Solutions [ECHOS] cost database (published by the R.S. Means Company)).
4. Costs are presented as feasibility study level estimates (the period of system operation and final budget costs are subject to design and subsequent detailed cost review).

Year 14 2018	Year 15 2019	Year 16 2020	Year 17 2021	Year 18 2022	Year 19 2023	Year 20 2024	Year 21 2025	Year 22 2026	Year 23 2027	Year 24 2028	Year 25 2029	Year 26 2030	Year 27 2031	Year 28 2032	Year 29 2033	Year 30 2034	TOTALS	TECHNOLOGY NAME
	$24,778					$24,778					$24,778					$24,778	$173,446	Five-Year Review
$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$14,114	$543,507	Equipment, Materials & Analytical For Groundwater Monitoring
$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$120,082	$3,914,826	Labor For Groundwater Monitoring
$134,196	$158,974	$134,196	$134,196	$134,196	$134,196	$158,974	$134,196	$134,196	$134,196	$134,196	$158,974	$134,196	$134,196	$134,196	$134,196	$158,974	$4,631,779	TOTALS

MEW Site File
3DISC104373

E

APPENDIX E

E HUMAN HEALTH RISK BASED TARGET CLEAN-UP LEVELS

The Baseline Human Health Risk Assessment (BHHRA) has shown that the incremental lifetime cancer risk (ILCR) and hazard index (HI) for a future off-Site resident using impacted groundwater could exceed the EPA acceptable limit of 10^{-6} to 10^{-4} and 1, respectively. Based on the results of the BHHRA, the chemicals of potential concern (COPCs) that showed a significant contribution (*i.e.*, a 10^{-4} cumulative site cancer risk or an HI of 1 is exceeded) to the risk associated with a future off-Site resident using impacted groundwater for water supply were considered chemicals of concern (COCs). A COPC was considered a COC if the individual carcinogenic risk contribution of the chemical is greater than 10^{-6}, and/or the non-carcinogenic hazard quotient (HQ) for the chemical is greater than 0.1. Chemicals considered COCs are listed as follows:

Table E.1: ILCR and HI for Each COC

COC		ILCR	COC		HQ
Aroclor-1260	D	2×10^{-3}	Chlorobenzene	D	75
Dibenzo(a,h)Anthracene	N	7×10^{-4}	1,2,4-Trichlorobenzene	D	18
Aroclor-1260	D	4×10^{-4}	Aroclor-1254	N	12
N-Nitrosodi-n-propylamine	D	3×10^{-4}	Benzene	D	4
Tetrachloroethene	D	3×10^{-4}	Trichloroethene	D	7
Bis(2-Chloroethyl) Ether	D	2×10^{-4}	Bis(2-ethylhexyl)phthalate	N	3
Trichloroethene	D	2×10^{-4}	Naphthalene	D	1
Benzo(a)pyrene	N	2×10^{-4}	Hexachloro-1,3-Butadiene	N	0.7
Benzene	D	8×10^{-5}	Hexachlorobenzene	N	0.3
Hexachlorobenzene	N	6×10^{-5}	Nitrobenzene	N	0.3
1,4-Dichlorobenzene	D	4×10^{-5}	Aroclor 1016	N	0.2
Pentachlorophenol	N	3×10^{-5}	1,4-Dichlorobenzene	D	0.2
Chloroform	D	3×10^{-5}	2,4,6-Trichlorophenol	N	0.2
Bis(2-ethylhexyl)phthalate	D	2×10^{-5}	1,3-Dichlorobenzene	D	0.2
Indeno(1,2,3-cd)Pyrene	N	2×10^{-5}	4,6-Dinitro-2-Methyl Phenol	D	0.1
Benzo(a)anthracene	N	1×10^{-5}	Pentachlorophenol	N	0.1
Benzo(b)fluoranthene	N	1×10^{-5}	1,2-Dichloroethane	N	0.1
2,6-Dinitrotoluene	N	10×10^{-6}	1,3-Dichloropropane	N	0.1
Aroclor-1254	N	9×10^{-6}	2-Chlorophenol	D	0.1
Aroclor-1242	N	6×10^{-6}	Chloroform	D	0.1
Benzo(k)fluoranthene	N	5×10^{-6}			
2,4-Dinitrotoluene	N	4×10^{-6}			
Aroclor-1016	N	3×10^{-6}			
Aroclor-1248	N	3×10^{-6}			
Hexachloro-1,3-Butadiene	N	2×10^{-6}			

Table E.1: ILCR and HI for Each COC

COC		ILCR	COC		HQ
Vinyl Chloride	N	2×10^{-6}			
3,3-Dichlorobenzidine	N	1×10^{-6}			
Aroclor-1221	N	1×10^{-6}			
Aroclor-1232	N	1×10^{-6}			

Notes: N = non-detectable COPC, D = detected COPC

The human health risk based target clean-up levels (TCLs) have been calculated iteratively using the algorithms, parameter values, calculated attenuation factors and assumptions presented in the BHHRA (Komex, 2005c). To ensure that the calculated TCLs are conservative, the predicted groundwater concentrations at Hypothetical Well D, worst case exposure scenario, have been used to calculate the tap water point of exposure (Komex, 2005c).

The human health risk based TCLs have been calculated iteratively using the following process:

1. Selection of the initial set of on-Site groundwater source concentrations using the off-Site resident hypothetical Well D scenario;
2. Calculation of POE concentrations;
3. Calculation of total ILCR and HI for the off-Site residential receptor for these point of exposure concentrations; and,
4. Derivation of on-Site groundwater source concentrations for each COC for which the individual ILCR is less than 10^{-6} and the HQ is less than 0.1 (0.05 was used to ensure the resulting cumulative HI would be less than 1). This is done using equation 1. Following additional adjustment of the resulting source concentrations to ensure that the cumulative ILCR and HI for the Site is within the EPA acceptable range, these concentrations become the human health risk based TCLs.

$$TCL_{coc} = \frac{EPC_{coc} * Target\ Risk_{coc}}{Calc.\ Risk_{coc}} \quad \text{..} (1)$$

Where,

TCL_{coc} = Target clean-up level for individual COC (ug/L)

EPC_{coc} = Exposure Point Concentrations for individual COC (ug/L)

$Target\ Risk_{coc}$ = Target risk level for COC - 1×10^{-6} for ILCR and 0.05 for HQ (unitless)

$Calc.\ Risk_{coc}$ = Calculated risk for individual COC for reasonable maximum exposure (RME) for hypothetical well D scenario

The human health risk based TCLs are presented below:

Table E.2: Risk Based Target Clean-Up Levels

COC	Risk Based Clean-up Level
Units	**(ug/L)**
1,2,4-Trichlorobenzene	0.17
1,2-Dichloroethane	0.22
1,2-Dichloropropane	0.015
1,3-Dichlorobenzene	28
1,4-Dichlorobenzene	2.9
2,4,6-Trichlorophenol	0.1
2,4-Dinitrotoluene	0.26
2,6-Dinitrotoluene	0.06
2-Chlorophenol	8.9
3,3-Dichlorobenzidine	0.74
4,6-Dinitro-2-Methyl Phenol	0.18
Aroclor-1016	0.05
Aroclor-1221	0.13
Aroclor-1232	0.13
Aroclor-1242	0.01
Aroclor-1248	0.02
Aroclor-1254	0.0004
Aroclor-1260	0.002
Benzene	0.97
Benzo(a)anthracene	0.05
Benzo(a)pyrene	0.003
Benzo(b)fluoranthene	0.08
Benzo(k)fluoranthene	0.15
Bis(2-Chloroethyl) Ether	0.02
Bis(2-ethylhexyl) phthalate	1.9
Chlorobenzene	2.1
Chloroform	0.4
Dibenzo(a,h)Anthracene	0.0009
Hexachloro-1,3-Butadiene	0.05
Hexachlorobenzene	0.01
Indeno(1,2,3-cd)Pyrene	0.04
Naphthalene	0.3
Nitrobenzene	0.18
N-Nitrosodi-n-propylamine	0.02
Pentachlorophenol	0.13
Tetrachloroethene	0.02
Trichloroethene	0.17
Vinyl Chloride	0.21

The calculated risks to the off-Site adult and child resident for these TCLs are summarized in Table E.3 and presented in Tables E.4 and E.5, respectively. To ensure that the calculated TCLs are conservative the highest cancer slope factor of 0.4 $mg^{-1}.kg.d$ has been assumed for Trichloroethene (Komex, 2005c).

Table E.3: Summary of Health Risk to Off-Site Resident Using Human Health Risk Based TCLs

HI		ILCR		ILCR summed for child + adult*
Child	Adult	Child	Adult	
0.9	0.4	3×10^{-5}	4×10^{-5}	7×10^{-5}

Note: *ICLRs have been calculated for the off-site resident for a 30 year exposure duration, including 6 years as a child and 24 years as an adult

MEW Site File
3DISC104378

TABLE E.4
RME Calculations for Adult Resident (HIGH TCE SLOPE FACTOR, WELL D)
Missouri Electric Works, Cape Girardeau

Source Medium	Exposure Medium	Exposure Point	Exposure Route	Parameter	Symbol	Units	Non Contaminant-Specific Parameters	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	Total 1,2 Dichloroethene	1,2,4 Trichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chlorophenol	3,3-Dichlorobenzidine	4,6-Dinitro-2-Methyl Phenol	Aroclor-1016	Aroclor-1221
								Chemicals of Potential Concern																
Groundwater	Air	Indoor air	Vapour intrusion - inhalation	POE concentration	C_{a-in}	ug/m3		7.59E-06	9.30E-05	2.27E-03	7.42E-03	4.09E-03	1.92E-04	1.06E-04	8.90E-03	6.16E-03	0.00E+00	0.00E+00	0.00E+00	3.06E-04	0.00E+00	0.00E+00	6.76E-08	0.00E+00
				POE concentration	C_{a-in}	mg/m3		7.59E-09	9.30E-08	2.27E-06	7.42E-06	4.09E-06	1.92E-07	1.06E-07	8.90E-06	6.16E-06	0.00E+00	0.00E+00	0.00E+00	3.06E-07	0.00E+00	0.00E+00	6.76E-11	0.00E+00
				Inhalation rate	IR	m3/hr	0.83																	
				Exposure time	ET	h/d	24																	
				Exposure frequency	EF	d/y	350																	
				Exposure duration	ED	y	24																	
				Body weight	BW	kg	70																	
				Averaging time carcinogens	AT_c	d	25,550																	
				Averaging time non-carcinogens	ATn_c	d	8,760																	
				Average intake from inhalation carcinogens	I_a	mg/kg-d		7.10103E-10	8.70087E-09	2.12376E-07	6.94198E-07	3.82651E-07	1.79631E-08	9.91712E-09	8.32664E-07	5.76314E-07	0	0	0	2.86287E-08	0	0	6.32458E-12	0
				Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg		2.03E-01	5.70E-02				9.10E-02			2.20E-02	1.09E-02						4.00E-01	4.00E-01
				Risk	R	fraction		1.44E-10	4.96E-10				1.63E-09			1.27E-08	0.00E+00						2.53E-12	0.00E+00
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from inhalation non-carcinogens	I_a	mg/kg-d		2.07113E-09	2.53775E-08	6.1943E-07	2.02475E-06	1.11607E-06	5.23923E-08	2.89249E-08	2.4286E-06	1.68092E-06	0	0	0	8.35003E-08	0	0	1.84465E-11	0
				Inhalation Reference Dose	RfD_{inh}	mg/kg-d						1.14E-03	1.40E-03	1.14E-03		2.30E-01								
				Hazard Quotient	HQ	mg/kg-d						0.000979005	3.74231E-05	2.53727E-05		7.30835E-06								
				Total Hazard Index	HI	mg/kg-d																		
	Groundwater	Tap Water	Ingestion of tap water	POE concentration	C_w	ug/l		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				POE concentration	C_w	mg/m3		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				Water ingestion rate	IR	l/d	2																	
				Exposure frequency	EF	d/y	350																	
				Exposure duration	ED	y	24																	
				Body weight	BW	kg	70																	
				Averaging time carcinogens	AT_c	d	25,550																	
				Averaging time non-carcinogens	ATn_c	d	8,760																	
				Average intake from ingestion carcinogens	I_o	mg/kg-d		8.6973E-07	1.45071E-06	0.00011473	0.000103045	0.000568485	2.54973E-06	1.36279E-06	0.000413213	0.000466098	1.81348E-06	1.04187E-05	2.49863E-06	3.33088E-05	2.79424E-06	1.79497E-06	2.15108E-06	1.24762E-06
				Ingestion Cancer Slope Factor	CSF_o	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	6.80E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		1.74E-07	8.27E-08				2.32E-07	9.27E-08		1.12E-05	1.99E-08	7.08E-06	1.67E-05		1.26E-06		8.60E-07	4.99E-07
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from ingestion non-carcinogens	I_o	mg/kg-d		2.53671E-06	4.23123E-06	0.00033463	0.000300548	0.001658082	7.43671E-06	3.97479E-06	0.001205205	0.001359452	5.28932E-06	3.03879E-05	7.28767E-06	9.71507E-05	8.14986E-06	5.23534E-06	6.27397E-06	3.6389E-06
				Ingestion Reference Dose	RfD_o	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		4.22785E-05	0.001057808	0.003346301	0.030054795	0.165808219	0.000371836	0.00361345	0.040173516	0.045315068	0.052893151	0.015193973	0.007287671	0.019430137		0.052353425	0.08962818	
				Total Hazard Index	HI	mg/kg-d																		
			Dermal contact with tap water	POE concentration	C_w	ug/l		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				event duration	tevent	hr	0.58																	
				absorbed dose per event	Daevent	mg/cm2-event		1.30453E-09	1.61619E-09	1.07231E-07	1.08663E-07	8.89856E-06	1.48291E-09	1.60454E-09	4.51893E-06	3.69637E-06	1.64297E-08	7.65966E-09	0	4.46181E-08	1.34155E-08	1.46268E-09	0	4.32331E-08
				Event frequency	EV	events/day	1																	
				Exposure duration	ED	y	24																	
				Exposure frequency	EF	d/y	350																	
				Skin surface area	SA	cm2	18,000																	
				Body weight	BW	kg	70																	
				Averaging time	AT	d/y	25,550																	
				Averaging time non-carcinogens	ATn_c	d	8,760																	
				Absorbed dose for carcinogens	DAD_c	mg/kg-d		1.10285E-07	1.36633E-07	9.06534E-06	9.18642E-06	0.000752286	1.25366E-07	1.35648E-07	0.000382031	0.000312491	1.38897E-06	6.47549E-07	0	3.77202E-06	1.13415E-06	1.23655E-07	0	3.65493E-06
				Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	8.00E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		2.21E-08	7.79E-09				1.14E-08	9.22E-09		7.50E-06	1.53E-08	5.18E-07	0.00E+00		5.10E-07		0.00E+00	1.46E-06
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d		3.21664E-07	3.98513E-07	2.64406E-05	2.67937E-05	0.002194166	3.65649E-07	3.95641E-07	0.001114257	0.000911433	4.05115E-06	1.88868E-06	0	1.10017E-05	3.30793E-06	3.60661E-07	0	1.06602E-05
				Dermal Reference Dose	RfD_{der}	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		5.36107E-06	9.96282E-05	0.000264406	0.002679372	0.21941663	1.82825E-05	0.000359673	0.037141891	0.03038111	0.040511538	0.000944342	0	0.002200343		0.003606606	0	
				Total Hazard Index	HI	mg/kg-d																		
	Air	Indoor Air	Vapors from tap water	Concentration in tap water	C_w	ug/l		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				Concentration in tap water	C_w	mg/m3		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				Volatilization factor	VF	dimensionless	0.0005	y	Y	Y	Y	Y	Y	Y	Y	Y				Y			Y	
(only calculated for COPC with Henry's Law > 1e-5 atm.m3/mol, those with a 'Y')				POE concentration	C_{a}	mg/m3		0.000046295	0.00007722	0.006107	0.005485	0.03026	0.00013572	0.00007254	0.021995	0.02481	0	0	0	0.001773	0	0	0.0001145	0
				Inhalation rate	IR	m3/hr	0.83																	
				Exposure time	ET	h/d	24																	
				Exposure frequency	EF	d/y	350																	
				Exposure duration	ED	y	24																	
				Body weight	BW	kg	70																	
				Averaging time carcinogens	AT_c	d	25,550																	
				Averaging time non-carcinogens	ATn_c	d	8,760																	
				Average intake from inhalation carcinogens	I_a	mg/kg-d		4.33126E-06	7.22453E-06	0.000571357	0.000513164	0.002831057	1.26977E-05	6.78668E-06	0.002057802	0.002321167	0	0	0	0.000165878	0	0	1.07124E-05	0

TABLE E.4
RME Calculations for Adult Resident (HIGH TCE SLOPE FACTOR, WELL D)
Missouri Electric Works, Cape Girardeau

Chemicals of Potential Concern

Exposure Route	Parameter	Symbol	Units	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260 (Filtered)	Benzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	bis(2-Chloroethyl) Ether
Vapour intrusion - inhalation	POE concentration	C_{a-in}	ug/m3	0.00E+00	3.48E-08	0.00E+00	5.00E-08	2.08E-06	2.17E-03	0.00E+00	0.00E+00	5.21E-08	0.00E+00	4.11E-04
	POE concentration	C_{a-in}	mg/m3	0.00E+00	3.48E-11	0.00E+00	5.00E-11	2.08E-09	2.17E-06	0.00E+00	0.00E+00	5.21E-11	0.00E+00	4.11E-07
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	AT_{nc}	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	3.25581E-12	0	4.67789E-12	1.946E-10	2.0302E-07	0	0	4.87436E-12	0	3.84522E-08
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	2.73E-02	3.08E-01	3.08E+00	3.08E-01	3.08E-01	1.16E+00
	Risk	R	fraction	0.00E+00	1.30E-12	0.00E+00	1.87E-12	7.78E-11	5.54E-09	0.00E+00	0.00E+00	1.50E-12	0.00E+00	4.46E-08
	Total carcinogenic risk for exposure route	R_t	fraction											
	Average intake from inhalation non-carcinogens	I_{nc}	mg/kg-d	0	9.49611E-12	0	1.36438E-11	5.67584E-10	5.92142E-07	0	0	1.42169E-11	0	1.12152E-07
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d						8.57E-03					
	Hazard Quotient	HQ	mg/kg-d						6.90948E-05					
	Total Hazard Index	HI	mg/kg-d											
Ingestion of tap water	POE concentration	C_w	ug/l	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616
	POE concentration	C_w	mg/m3	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616
	Water ingestion rate	IR	l/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	AT_{nc}	d											
	Average intake from ingestion carcinogens	I_c	mg/kg-d	1.50575E-06	8.60431E-07	5.5928E-07	9.46474E-07	3.87194E-05	0.000711358	6.10906E-06	5.67884E-06	8.6624E-06	4.99068E-06	5.2753E-05
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	5.50E-02	7.30E-01	7.30E+00	7.30E-01	7.30E-02	1.10E+00
	Risk	R	fraction	6.02E-07	3.44E-07	2.24E-07	3.79E-07	1.55E-05	3.91E-05	4.46E-06	4.15E-05	6.32E-06	3.64E-07	5.80E-05
	Total carcinogenic risk for exposure route	R_t	fraction											
	Average intake from ingestion non-carcinogens	I_{nc}	mg/kg-d	4.39178E-06	2.50959E-06	1.631123E-06	2.76055E-06	0.000112932	0.002074795	1.78181E-05	1.65633E-05	2.52653E-05	1.45562E-05	0.000153863
	Ingestion Reference Dose	RfD_o	mg/kg-d				2.00E-05		4.00E-03					
	Hazard Quotient	HQ	mg/kg-d				0.138027397		0.51869863					
	Total Hazard Index	HI	mg/kg-d											
Dermal contact with tap water	POE concentration	C_w	ug/l	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616
	event duration	tevent	hr											
	absorbed dose per event	Daevent	mg/cm2-even	5.21778E-08	2.28188E-07	1.59109E-07	4.27428E-07	0.000109202	1.28037E-06	9.16736E-07	1.46103E-06	2.26152E-06	1.28432E-06	1.72638E-08
	Event frequency	EV	events/day											
	Exposure duration	ED	y											
	Exposure frequency	EF	d/y											
	Skin surface area	SA	cm2											
	Body weight	BW	kg											
	Averaging time	AT	d/y											
	Averaging time non-carcinogens	AT_{nc}	d											
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	4.41112E-06	1.92911E-05	1.34511E-05	3.61348E-05	0.009231943	0.000108242	7.7501E-06	0.000123515	0.000191189	0.000108577	1.45949E-06
	Dermal Cancer Slope Factor	CSF_{derm}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	5.50E-02	2.35E-01	2.35E+00	2.30E-02	7.30E-02	1.10E+00
	Risk	R	fraction	1.76E-06	7.72E-06	5.38E-06	1.45E-05	3.69E-03	5.95E-06	1.82E-05	2.90E-04	4.40E-06	7.93E-06	1.61E-06
	Total carcinogenic risk for exposure route	R_t	fraction											
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	1.28658E-05	5.62656E-05	3.92325E-05	0.000105393	0.0269265	0.000315707	0.000226045	0.000360253	0.000557635	0.000316682	4.25684E-06
	Dermal Reference Dose	RfD_{derm}	mg/kg-d				2.00E-05		4.00E-03					
	Hazard Quotient	HQ	mg/kg-d				5.269657043		0.078926641					
	Total Hazard Index	HI	mg/kg-d											
Vapors from tap water	Concentration in tap water	C_w	ug/l	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616
	Concentration in tap water	C_w	mg/m3	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616
	Volatilization factor	VF	dimensionless		y		y	y	y			y		y
3/mol, those with a 'Y')	POE concentration	C_{a-vap}	mg/m3	0	0.0000458	0	0.00005038	0.002061	0.037865	0	0	0.000461093	0	0.002808
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	AT_{nc}	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	4.28494E-06	0	4.71344E-06	0.000192822	0.003542563	0	0	4.31388E-05	0	0.00026271

Exposure Route	Parameter	Symbol	Units	bis(2-Chloroisopropyl) Ether	bis (2-ethylhexyl) phthalate	Bromodichloromethane	Carbon Tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroform	Dibenzo(a,h)Anthracene	Dibenzofuran	Hexachloro-1,3-Butadiene	Hexachlorobenzene
Vapour intrusion - inhalation	POE concentration	C_{a-in}	ug/m3	0.00E+00	0.00E+00	1.20E-03	3.04E-05	1.52E+00	9.87E-05	1.13E-02	0.00E+00	3.25E-04	7.48E-07	1.20E-06
	POE concentration	C_{a-in}	mg/m3	0.00E+00	0.00E+00	1.20E-06	3.04E-08	1.52E-03	9.87E-08	1.13E-05	0.00E+00	3.25E-07	7.48E-10	1.20E-09
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	AT_{nc}	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	0	1.12269E-07	2.84415E-09	0.000142208	9.23415E-09	1.0572E-06	0	3.04063E-08	6.99812E-11	1.12269E-10
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg				5.20E-02			8.10E-02	3.08E-01		7.70E-02	1.61E+00
	Risk	R	fraction				1.48E-10			8.56E-08	0.00E+00		5.39E-12	1.81E-10
	Total carcinogenic risk for exposure route	R_t	fraction											
	Average intake from inhalation non-carcinogens	I_{nc}	mg/kg-d	0	0	3.27452E-07	8.29545E-09	0.000414773	2.69329E-08	3.08351E-06	0	8.86849E-08	2.04112E-10	3.27452E-10
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d					1.70E-02						
	Hazard Quotient	HQ	mg/kg-d					0.024398368						
	Total Hazard Index	HI	mg/kg-d											
Ingestion of tap water	POE concentration	C_w	ug/l	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	POE concentration	C_w	mg/m3	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	Water ingestion rate	IR	l/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	AT_{nc}	d											
	Average intake from ingestion carcinogens	I_c	mg/kg-d	7.64919E-06	0.001032517	2.19804E-05	7.77205E-07	0.027251789	1.8024E-06	0.000114296	4.63421E-06	7.09855E-06	6.41021E-06	6.36719E-06
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
	Risk	R	fraction		1.45E-05	1.36E-06	1.01E-07		1.51E-07		3.38E-05		5.00E-07	1.02E-05
	Total carcinogenic risk for exposure route	R_t	fraction											
	Average intake from ingestion non-carcinogens	I_{nc}	mg/kg-d	2.23101E-05	0.003011507	6.41096E-05	2.26685E-06	0.079484384	5.25699E-06	0.00033337	1.35164E-05	2.07041E-05	1.86964E-05	1.8571E-05
	Ingestion Reference Dose	RfD_o	mg/kg-d	4.00E-02	2.00E-02	2.00E-02	7.00E-04	2.00E-02	2.00E-02	1.00E-02		4.00E-03	2.00E-04	8.00E-04
	Hazard Quotient	HQ	mg/kg-d	0.000557753	0.150575342	0.003205479	0.003238356	3.974219178	0.000262849	0.033336986		0.005176027	0.093482192	0.023213699
	Total Hazard Index	HI	mg/kg-d											
Dermal contact with tap water	POE concentration	C_w	ug/l	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	event duration	tevent	hr											
	absorbed dose per event	Daevent	mg/cm2-even	8.77868E-08	1.8825E-05	2.13911E-08	2.50372E-09	0.00011633	1.63014E-09	1.2333E-07	1.85163E-06	1.51142E-07	1.84025E-07	3.52242E-07
	Event frequency	EV	events/day											
	Exposure duration	ED	y											
	Exposure frequency	EF	d/y											
	Skin surface area	SA	cm2											
	Body weight	BW	kg											
	Averaging time	AT	d/y											
	Averaging time non-carcinogens	AT_{nc}	d											
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	7.4215E-06	0.001591465	1.8084E-06	2.11665E-07	0.009834593	1.37813E-07	1.04263E-05	0.000156537	1.27775E-05	1.55575E-05	2.97786E-05
	Dermal Cancer Slope Factor	CSF_{derm}	kg-d/mg		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
	Risk	R	fraction		2.23E-05	1.12E-07	2.75E-08		1.16E-08		1.14E-03		1.21E-06	4.76E-05
	Total carcinogenic risk for exposure route	R_t	fraction											
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	2.1646E-05	0.004641774	5.27451E-06	6.17355E-07	0.02868423	4.01954E-07	3.04101E-05	0.000456565	3.72678E-05	4.5376E-05	8.68542E-05
	Dermal Reference Dose	RfD_{derm}	mg/kg-d	4.00E-02	3.80E-03	2.00E-02	7.00E-04	6.20E-03	2.00E-02	2.00E-03		4.00E-03	2.00E-04	8.00E-04
	Hazard Quotient	HQ	mg/kg-d	0.000541151	1.221519561	0.000263726	0.000881936	4.626488708	2.00977E-05	0.015205032		0.00931695	0.226879999	0.108567769
	Total Hazard Index	HI	mg/kg-d											
Vapors from tap water	Concentration in tap water	C_w	ug/l	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	Concentration in tap water	C_w	mg/m3	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	Volatilization factor	VF	dimensionless			y	y	y	y	y		y	y	y
3/mol, those with a 'Y')	POE concentration	C_{a-vap}	mg/m3	0	0	0.00117	0.00004137	1.45059	0.00009594	0.006084	0	0.00037785	0.00034121	0.00033892
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	AT_{nc}	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	0	0.000109463	3.87048E-06	0.135713907	8.97593E-06	0.000569205	0	3.53508E-05	3.19228E-05	3.17086E-05

TABLE E.4
RME Calculations for Adult Resident (HIGH TCE SLOPE FACTOR, WELL D)
Missouri Electric Works, Cape Girardeau

Exposure Route	Parameter	Symbol	Units	Indeno(1,2,3-cd)Pyrene	2-methylnaphthalene	Naphthalene	Nitrobenzene	Nitrosodi-n-propylamine	Pentachlorophenol	Tetrachloroethene	Trichloroethene	Vinyl Chloride	Total	% Contribution
				Chemicals of Potential Concern										
Vapour intrusion - inhalation	POE concentration	C_{o-a}	ug/m3	0.00E+00		2.75E-04	6.87E-06	0.00E+00	0.00E+00	1.31E-03	2.50E-02	9.36E-04		
	POE concentration	C_{o-a}	mg/m3	0.00E+00		2.75E-07	6.87E-09	0.00E+00	0.00E+00	1.31E-06	2.50E-05	9.36E-07		
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	ATn_c	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0		2.57284E-08	6.42742E-10	0	0	1.22561E-07	2.33894E-06	8.757E-08		
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	3.08E-01						2.10E+00	4.00E-01	3.00E-02		
	Risk	R	fraction	0.00E+00						2.57E-07	9.36E-07	2.63E-09		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]	0%
	Average intake from inhalation non-carcinogens	I_n	mg/kg-d	0		7.50411E-08	1.87466E-09	0	0	3.57468E-07	6.82192E-06	2.55413E-07		
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d			8.57E-04	5.71E-04			1.40E-01	1.14E-02	2.86E-02		
	Hazard Quotient	HQ	mg/kg-d			8.75625E-05	3.28312E-06			2.55335E-06	0.000598414	8.93051E-06		
	Total Hazard Index	HI	mg/kg-d										[redacted]	0%
Ingestion of tap water	POE concentration	C_w	ug/l	0.5313		3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	POE concentration	C_w	mg/m3	0.5313		3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	Water ingestion rate	IR	l/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	ATn_c	d											
	Average intake from ingestion carcinogens	I_c	mg/kg-d	4.99068E-06		3.21985E-05	3.47892E-06	7.12166E-05	3.88915E-05	5.06301E-05	0.000143249	3.20914E-06		
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	7.30E-01				7.00E+00	1.20E-01	5.40E-01	4.00E-01	7.20E-01		
	Risk	R	fraction	3.64E-06				4.99E-04	4.67E-06	2.73E-05	5.73E-05	2.31E-06		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]	11%
	Average intake from ingestion non-carcinogens	I_n	mg/kg-d	1.45562E-05		9.39123E-05	1.01468E-05	0.000207715	0.000113433	0.000147671	0.000417808	0.00000936		
	Ingestion Reference Dose	RfD_o	mg/kg-d			2.00E-02	5.00E-04		3.00E-02	1.00E-02	3.00E-04	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d			0.004695616	0.020293699		0.003781114	0.014767123	1.392694064	0.00312		
	Total Hazard Index	HI	mg/kg-d										[redacted]	13%
Dermal contact with tap water	POE concentration	C_w	ug/l	0.5313		3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	event duration	tevent	hr											
	absorbed dose per event	Daevent	mg/cm2-even	1.35781E-06		2.5123E-07	3.03574E-09	2.81779E-08	5.58223E-06	3.61079E-07	2.84781E-07	2.01884E-09		
	Event frequency	EV	events/day											
	Exposure duration	ED	y											
	Exposure frequency	EF	d/y											
	Skin surface area	SA	cm2											
	Body weight	BW	kg											
	Averaging time	AT	d/y											
	Averaging time non-carcinogens	ATn_c	d											
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	0.000114789		2.1239E-05	2.56642E-07	2.38216E-06	0.000471922	3.05257E-05	2.40754E-05	1.70673E-07		
	Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg	2.30E-01				1.80E+00	1.20E-01	5.40E-01	6.00E-02	7.20E-01		
	Risk	R	fraction	2.64E-05				4.29E-06	5.66E-05	1.65E-05	1.44E-06	1.23E-07		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]5.38E-03	70%
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	0.000334801		6.19472E-05	7.48538E-07	6.94796E-06	0.001376441	8.90332E-05	7.022E-05	4.97795E-07		
	Dermal Reference Dose	RfD_{der}	mg/kg-d		4.00E-03	2.00E-02	5.00E-04		3.00E-02	1.00E-02	4.50E-05	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d			0.00309736	0.001497076		0.045881353	0.008903317	1.560445485	0.000165932		
	Total Hazard Index	HI	mg/kg-d										1.35E+01	25%
Vapors from tap water	Concentration in tap water	C_w	ug/l	0.5313		3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	Concentration in tap water	C_w	mg/m3	0.5313		3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	Volatilization factor	VF	dimensionless	Y	Y	Y				Y	Y	Y		
i3/mol, those with a "Y")	POE concentration	C_{a-tap}	mg/m3	0		0.0017139	0.00018518	0	0	0.002695	0.007625	0.00017082		
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	ATn_c	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0		0.000160349	1.7325E-05	0	0	0.000252138	0.000713378	1.59815E-05		

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TABLE E.4
RME Calculations for Adult Resident (HIGH TCE SLOPE FACTOR, WELL D)
Missouri Electric Works, Cape Girardeau

Chemicals of Potential Concern

Source Medium	Exposure Medium	Exposure Point	Exposure Route	Parameter	Symbol	Units	Non Contaminant-Specific Parameters	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	Total 1,2 Dichloroethene	1,2,4 Trichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chlorophenol	3,3-Dichlorobenzidine	4,6-Dinitro-2-Methyl Phenol	Aroclor-1016	Aroclor-1221
				Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg		2.03E-01	5.70E-02				9.10E-02			2.20E-02	1.09E-02						4.00E-01	4.00E-01
				Risk	R	fraction		8.79E-07	4.12E-07				1.16E-06			5.11E-05	0.00E+00						4.28E-06	0.00E+00
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from inhalation non-carcinogens	I_a	mg/kg-d		1.26328E-05	2.10715E-05	0.001666458	0.001496729	0.008257249	3.70348E-05	1.97945E-05	0.006001923	0.006770071	0	0	0	0.00048381	0	0	3.12444E-05	0
				Inhalation Reference Dose	RfD_{inh}	mg/kg-d						1.14E-03	1.40E-03	1.14E-03		2.30E-01								
				Hazard Quotient	HQ	mg/kg-d						7.243201154	0.026453448	0.017363576		0.029435092								
				Total Hazard Index	HI	mg/kg-d																		
	Surface Water	Creek	Incidental ingestion of creek water	POE concentration	C_w	ug/l		3.87145E-05	0.00014692	0.005107025	0.168484251	0.003415705	0.000258223	0.000138016	0.277239592	0.332753253	8.07239E-05	0.001055151	0.0001112	0.001482685	0.000124381	7.99002E-05	4.276E-07	2.47989E-07
				POE concentration	C_w	mg/m3		3.87145E-05	0.00014692	0.005107025	0.168484251	0.003415705	0.000258223	0.000138016	0.277239592	0.332753253	8.07239E-05	0.001055151	0.0001112	0.001482685	0.000124381	7.99002E-05	4.276E-07	2.47989E-07
				Water ingestion rate	IR	l/d	0.05																	
				Exposure frequency	EF	d/y	52																	
				Exposure duration	ED	y	24																	
				Body weight	BW	kg	70																	
				Averaging time carcinogens	AT_c	d	25.550																	
				Averaging time non-carcinogens	ATn_c	d	8.760																	
				Average intake from ingestion carcinogens	I_o	mg/kg-d		1.35073E-12	5.12597E-12	1.78182E-10	5.87834E-09	1.19172E-10	9.00928E-12	4.8153E-12	9.67277E-09	1.16096E-08	2.81642E-12	3.68138E-11	3.87972E-12	5.17302E-11	4.33959E-12	2.78768E-12	1.49188E-14	8.65223E-15
				Ingestion Cancer Slope Factor	CSF_o	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	6.80E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		2.70E-13	2.92E-13				8.20E-13	3.27E-13		2.79E-10	3.10E-14	2.50E-11	2.60E-11		1.95E-12		5.97E-15	3.46E-15
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from ingestion non-carcinogens	I_o	mg/kg-d		3.93964E-12	1.49507E-11	5.19697E-10	1.71452E-08	3.47586E-10	2.62771E-11	1.40446E-11	2.82122E-08	3.38614E-08	8.21457E-12	1.07373E-10	1.13159E-11	1.5088E-10	1.26571E-11	8.13075E-12	4.35131E-14	2.52357E-14
				Ingestion Reference Dose	RfD_o	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		6.56607E-11	3.73769E-09	5.19697E-09	1.71452E-06	3.47586E-08	1.31385E-09	1.27678E-08	9.40408E-07	1.12871E-06	8.21457E-08	5.36867E-08	1.13159E-08	3.0176E-08		8.13075E-08	6.21616E-10	
				Total Hazard Index	HI	mg/kg-d																		
			Dermal contact with creek water	POE concentration	C_w	ug/l		3.87145E-05	0.00014692	0.005107025	0.168484251	0.003415705	0.000258223	0.000138016	0.277239592	0.332753253	8.07239E-05	0.001055151	0.0001112	0.001482685	0.000124381	7.99002E-05	4.276E-07	2.47989E-07
				event duration	tevent	hr	2																	
				absorbed dose per event	Daevent	mg/cm2-event		1.01289E-12	2.99941E-12	9.41817E-11	3.52119E-09	9.32615E-10	2.97547E-12	3.08949E-12	5.39677E-08	4.70013E-08	1.27568E-11	1.3531E-11	0	3.66143E-11	1.04164E-11	1.13569E-12	0	1.49895E-13
				Event frequency	EV	events/day	1																	
				Exposure duration	ED	y	24																	
				Exposure frequency	EF	d/y	52																	
				Skin surface area	SA	cm2	18.000																	
				Body weight	BW	kg	70																	
				Averaging time	AT	d/y	25.550																	
				Averaging time non-carcinogens	ATn_c	d	8.760																	
				Absorbed dose for carcinogens	DAD_c	mg/kg-d		1.27222E-11	3.76733E-11	1.18295E-09	4.4227E-08	1.17139E-08	3.73727E-11	3.88048E-11	6.77847E-07	5.90347E-07	1.60228E-10	1.69953E-10	0	4.59884E-10	1.30832E-10	1.42646E-11	0	1.88271E-12
				Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	8.00E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		2.54E-12	2.15E-12				3.40E-12	2.64E-12		1.42E-08	1.76E-12	1.36E-10	0.00E+00		5.89E-11		0.00E+00	7.53E-13
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d		3.71064E-11	1.0988E-10	3.45026E-09	1.28995E-07	3.41655E-08	1.09004E-10	1.13181E-10	1.97705E-06	1.72185E-06	4.67332E-10	4.95697E-10	0	1.34133E-09	3.81594E-10	4.16049E-11	0	5.49125E-12
				Dermal Reference Dose	RfD_{der}	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		6.1844E-10	2.74701E-08	3.45026E-08	1.28995E-05	3.41655E-06	5.45018E-09	1.02891E-07	6.59018E-05	5.73949E-05	4.67332E-06	2.47848E-07	0	2.68266E-07		4.16049E-07	0	
				Total Hazard Index	HI	mg/kg-d																		
			Carcinogenic risk - all routes (detected organics)																					
			Carcinogenic risk - all routes (undetected organics)																					
			TOTAL CARCINOGENIC RISK - ALL ROUTES		Sum Rt	fraction		1.08E-06	5.03E-07	0.00E+00	0.00E+00	0.00E+00	1.40E-06	1.02E-07	0.00E+00	6.98E-05	3.52E-08	7.60E-06	1.67E-05	0.00E+00	1.77E-06	0.00E+00	5.15E-06	1.96E-06
			Non-Carcinogenic risk - all routes (detected organics)																					
			Non-Carcinogenic risk - all routes (undetected organics)																					
			TOTAL NON-CARCINOGENIC HAZARD INDEX - ALL ROUTES		Sum HI	fraction		4.76403E-05	0.001157468	0.003610747	0.032748781	7.629408459	0.026880996	0.021362187	0.077382249	0.105197103	0.093409444	0.016138616	0.007287683	0.021630778	0	0.055960528	0.089628181	0

Notes:
1- ug/l = micrograms per liter
2- ug/m3 = micrograms per cubic meter
3- h/d = hours per day
4- l/d = liters per day
5- d/y = days per year
6- y = year
7- kg = kilogram
8- d = day
9- hr = hour
10- mg/kg-d = milligrams per kilogram per day
11- kg-d/mg = kilograms per day per milligram
12- cm2 = square centimeter
13- m3/hr = cubic meter per hour
14- mg/m3 = milligrams per cubic meter
15- mg/cm2-event = milligrams per square centimeter per event
16- mg/cm3-event = milligrams per cubic centimeter per event

MEW Site File
3DISC104382

TABLE E.4
RME Calculations for Adult Resident (HIGH TCE SLOPE FACTOR, WELL D)
Missouri Electric Works, Cape Girardeau

Exposure Route	Parameter	Symbol	Units	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260 (Filtered)	Benzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	bis(2-Chloroethyl) Ether	bis(2-Chloroisopropyl) Ether	Bis (2-ethylhexyl phthalate)	Bromodichloromethane	Carbon Tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroform	Dibenzo(a,h)Anthracene	Dibenzofuran	Hexachloro-1,3-Butadiene	Hexachlorobenzene
				Chemicals of Potential Concern																					
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	2.73E-02	3.08E-01	3.08E+00	3.08E-01	3.08E-01	1.16E+00				5.20E-02			8.10E-02	3.08E-01		7.70E-02	1.61E+00
	Risk	R	fraction	0.00E+00	1.71E-06	0.00E+00	1.89E-06	7.71E-05	9.67E-05	0.00E+00	0.00E+00	1.33E-05	0.00E+00	3.05E-04				2.01E-07			4.61E-05	0.00E+00		2.46E-06	5.11E-05
	Total carcinogenic risk for exposure route	R_t	fraction																						
	Average intake from inhalation non-carcinogens	I_n	mg/kg-d	0	1.24978E-05	0	1.37475E-05	0.000562399	0.010332477	0	0	0.000125821	0	0.000766238	0	0	0.000319266	1.12889E-05	0.39583223	2.61798E-05	0.001660182	0	0.000103106	9.31083E-06	9.24834E-06
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d						8.57E-03										1.70E-02						
	Hazard Quotient	HQ	mg/kg-d						1.205656559										23.28424883						
	Total Hazard Index	HI	mg/kg-d																						
Incidental ingestion of creek water	POE concentration	C_w	ug/l	2.99297E-07	1.71027E-07	1.11168E-07	1.8813E-07	7.69621E-06	0.003648704	1.21429E-06	1.12878E-06	9.13887E-09	5.26519E-09	0.005342537	0.000774668	0.000205232	0.002226	3.4596E-05	1.35956262	0.000182537	0.011575497	4.88911E-09	1.41097E-06	1.27415E-06	4.00642E-06
	POE concentration	C_w	mg/m3	2.99297E-07	1.71027E-07	1.11168E-07	1.8813E-07	7.69621E-06	0.003648704	1.21429E-06	1.12878E-06	9.13887E-09	5.26519E-09	0.005342537	0.000774668	0.000205232	0.002226	3.4596E-05	1.35956262	0.000182537	0.011575497	4.88911E-09	1.41097E-06	1.27415E-06	4.00642E-06
	Water ingestion rate	IR	l/d																						
	Exposure frequency	EF	d/y																						
	Exposure duration	ED	y																						
	Body weight	BW	kg																						
	Averaging time carcinogens	AT_c	d																						
	Averaging time non-carcinogens	AT_{nc}	d																						
	Average intake from ingestion carcinogens	I_c	mg/kg-d	1.04423E-14	5.96706E-15	3.87859E-15	6.56376E-15	2.68518E-13	1.27302E-10	4.23661E-14	3.93826E-14	3.18851E-16	1.837E-16	1.86399E-10	2.70278E-11	7.16047E-12	7.76642E-11	1.20704E-12	4.74346E-08	6.36863E-12	4.03864E-10	1.70579E-16	4.92282E-14	4.44546E-14	1.39782E-13
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01		7.30E-01	7.30E+00	7.30E-01	7.30E-02	1.10E+00		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
	Risk	R	fraction	4.18E-15	2.39E-15	1.55E-15	2.63E-15	1.07E-13	7.00E-12	3.09E-14	2.87E-13	2.33E-16	1.34E-17	2.05E-10		1.00E-13	4.82E-12	1.57E-13		5.35E-13		1.25E-15		3.47E-15	2.24E-13
	Total carcinogenic risk for exposure route	R_t	fraction																						
	Average intake from ingestion non-carcinogens	I_n	mg/kg-d	3.04569E-14	1.74039E-14	1.13125E-14	1.91443E-14	7.83176E-13	3.71297E-10	1.23568E-13	1.14866E-13	9.29983E-16	5.35793E-16	5.43663E-10	7.88312E-11	2.08847E-11	2.26521E-10	3.52053E-12	1.38351E-07	1.85752E-11	1.17794E-09	4.97522E-16	1.43582E-13	1.29659E-13	4.07698E-13
	Ingestion Reference Dose	RfD_o	mg/kg-d				2.00E-05		4.00E-03						4.00E-02	2.00E-02	2.00E-02	7.00E-04	2.00E-02	2.00E-02	1.00E-02		4.00E-03	2.00E-04	8.00E-04
	Hazard Quotient	HQ	mg/kg-d				9.57215E-10		9.28242E-08						1.97078E-09	1.04423E-09	1.1326E-08	5.02933E-09	6.91754E-06	9.28758E-10	1.17794E-07		3.58956E-11	6.48296E-10	5.09623E-10
	Total Hazard Index	HI	mg/kg-d																						
Dermal contact with creek water	POE concentration	C_w	ug/l	2.99297E-07	1.71027E-07	1.11168E-07	1.8813E-07	7.69621E-06	0.003648704	1.21429E-06	1.12878E-06	9.13887E-09	5.26519E-09	0.005342537	0.000774668	0.000205232	0.002226	3.4596E-05	1.35956262	0.000182537	0.011575497	4.88911E-09	1.41097E-06	1.27415E-06	4.00642E-06
	event duration	tevent	hr																						
	absorbed dose per event	Daevent	mg/cm2-even	1.80907E-13	7.91158E-13	5.51653E-13	1.48195E-12	3.78617E-10	1.36534E-10	3.17844E-12	5.06557E-12	4.16175E-14	2.36346E-14	3.17633E-11	1.55078E-10	6.52686E-11	3.77871E-11	1.99165E-12	1.07752E-07	2.8797E-12	2.34503E-10	3.40744E-14	5.24028E-13	6.38038E-13	3.86609E-12
	Event frequency	EV	events/day																						
	Exposure duration	ED	y																						
	Exposure frequency	EF	d/y																						
	Skin surface area	SA	cm2																						
	Body weight	BW	kg																						
	Averaging time	AT	d/y																						
	Averaging time non-carcinogens	AT_{nc}	d																						
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	2.27224E-12	9.93714E-12	6.7287E-12	1.86136E-11	4.75552E-09	1.7149E-09	3.9922E-11	6.36248E-11	5.22726E-13	2.96857E-13	3.98954E-10	1.94782E-09	8.1979E-10	4.74616E-10	2.50156E-11	1.35339E-06	3.61698E-11	2.94541E-09	4.27983E-13	6.58192E-12	8.01392E-12	4.8559E-11
	Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	5.50E-02	2.35E-01	2.35E+00	2.30E-02	7.30E-02	1.10E+00		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
	Risk	R	fraction	9.09E-13	3.97E-12	2.77E-12	7.45E-12	1.90E-09	9.43E-11	9.38E-12	1.50E-10	1.20E-14	2.17E-14	4.39E-10		1.15E-11	2.94E-11	3.25E-12		3.04E-12		3.12E-12		6.25E-13	7.77E-11
	Total carcinogenic risk for exposure route	R_t	fraction																						
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	6.62737E-12	2.89833E-11	2.02093E-11	5.42897E-11	1.38703E-08	5.0018E-09	1.16439E-10	1.85572E-10	1.52462E-12	8.65833E-13	1.16362E-09	5.68114E-09	2.39105E-09	1.38429E-09	7.29622E-11	3.94738E-06	1.05495E-10	8.59079E-09	1.24828E-12	1.91973E-11	2.33739E-11	1.4163E-10
	Dermal Reference Dose	RfD_{der}	mg/kg-d				2.00E-05		4.00E-03						4.00E-02	3.80E-03	2.00E-02	7.00E-04	6.20E-03	2.00E-02	2.00E-03		4.00E-03	2.00E-04	8.00E-04
	Hazard Quotient	HQ	mg/kg-d				2.71449E-06		1.25045E-06						1.42028E-07	6.29225E-07	6.92147E-08	1.04232E-07	0.000636674	5.27476E-09	4.29541E-06		4.79931E-09	1.16870E-07	1.77038E-07
	Total Hazard Index	HI	mg/kg-d																						
Carcinogenic risk - all routes (detected organics)																									
Carcinogenic risk - all routes (undetected organics)																									
TOTAL CARCINOGENIC RISK - ALL ROUTES		Sum Rt	fraction	2.37E-06	9.77E-06	5.60E-06	1.67E-05	3.79E-03	1.42E-04	2.27E-05	3.32E-04	2.40E-05	8.29E-06	3.64E-04	0.00E+00	3.67E-05	1.47E-06	3.30E-07	0.00E+00	1.63E-07	4.62E-05	1.18E-03	0.00E+00	4.17E-06	1.09E-04
Non-Carcinogenic risk - all routes (detected organics)																									
Non-Carcinogenic risk - all routes (undetected organics)																									
TOTAL NON-CARCINOGENIC HAZARD INDEX - ALL ROUTES		Sum HI	fraction	0	0	0	5.407687156	0	1.803352269	0	0	0	0	0	0.001099049	1.372095534	0.003469286	0.004120401	31.9099987	0.000282953	0.048546432	0	0.014492982	0.320362308	0.131781645

MEW Site File
3DISC104383

TABLE E.4
RME Calculations for Adult Resident (HIGH TCE SLOPE FACTOR, WELL D)
Missouri Electric Works, Cape Girardeau

Exposure Route	Parameter	Symbol	Units	Indeno(1,2,3-cd)Pyrene	2-methylnaphthalene	Naphthalene	Nitrobenzene	Nitrosodi-n-propylamine	Pentachlorophenol	Tetrachloroethene	Trichloroethene	Vinyl Chloride	Total	% Contribution
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	3.08E-01						2.10E+00	4.00E-01	3.00E-02		
	Risk	R	fraction	0.00E+00						5.29E-04	2.85E-04	4.79E-07		
	Total carcinogenic risk for exposure route	R_t	fraction										[illegible]	19%
	Average intake from inhalation non-carcinogens	I_n	mg/kg-d	0		0.000467683	5.05313E-05	0	0	0.000735403	0.002080685	4.66128E-05		
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d			8.57E-04	5.71E-04			1.40E-01	1.14E-02	2.86E-02		
	Hazard Quotient	HQ	mg/kg-d			0.545721584	0.088496164			0.005252877	0.182516222	0.001629818		
	Total Hazard Index	HI	mg/kg-d										[illegible]	61%
Incidental ingestion of creek water	POE concentration	C_w	ug/l	5.26519E-09		0.001433262	0.000154858	0.007212425	7.73042E-06	0.000841116	0.029336582	0.000325004		
	POE concentration	C_w	mg/m3	5.26519E-09		0.001433262	0.000154858	0.007212425	7.73042E-06	0.000841116	0.029336582	0.000325004		
	Water ingestion rate	IR	l/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	ATn_c	d											
	Average intake from ingestion carcinogens	I_c	mg/kg-d	1.837E-16		5.00059E-11	5.40294E-12	2.51638E-10	2.69711E-13	2.93462E-11	1.02354E-09	1.13393E-11		
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	7.30E-01				7.00E+00	1.20E-01	5.40E-01	4.00E-01	7.20E-01		
	Risk	R	fraction	1.34E-16				1.76E-09	3.24E-14	1.58E-11	4.09E-10	8.16E-12		
	Total carcinogenic risk for exposure route	R_t	fraction										[illegible]	0%
	Average intake from ingestion non-carcinogens	I_n	mg/kg-d	5.35793E-16		1.45851E-10	1.57586E-11	7.33945E-10	7.86657E-13	8.5593E-11	2.98533E-09	3.30728E-11		
	Ingestion Reference Dose	RfD_o	mg/kg-d			2.00E-02	5.00E-04		3.00E-02	1.00E-02	3.00E-04	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d			7.29253E-09	3.15171E-08		2.62219E-11	8.5593E-09	9.95109E-06	1.10243E-08		
	Total Hazard Index	HI	mg/kg-d										[illegible]	0%
Dermal contact with creek water	POE concentration	C_w	ug/l	5.26519E-09		0.001433262	0.000154858	0.007212425	7.73042E-06	0.000841116	0.029336582	0.000325004		
	event duration	tevent	hr											
	absorbed dose per event	Daevent	mg/cm2-even	2.49869E-14		2.00333E-10	2.52675E-12	5.27912E-11	1.93543E-11	1.04633E-10	1.06659E-09	4.46083E-12		
	Event frequency	EV	events/day											
	Exposure duration	ED	y											
	Exposure frequency	EF	d/y											
	Skin surface area	SA	cm2											
	Body weight	BW	kg											
	Averaging time	AT	d/y											
	Averaging time non-carcinogens	ATn_c	d											
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	3.13842E-13		2.51624E-09	3.17365E-11	6.6307E-10	2.43095E-10	1.31422E-09	1.33966E-08	8.60291E-11		
	Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg	2.30E-01				1.80E+00	1.20E-01	5.40E-01	6.00E-02	7.20E-01		
	Risk	R	fraction	7.22E-14				1.19E-09	2.92E-11	7.10E-10	8.04E-10	4.03E-11		
	Total carcinogenic risk for exposure route	R_t	fraction										1.99E-08	0%
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	9.15373E-13		7.33902E-09	9.25649E-11	1.93395E-09	7.09027E-10	3.83315E-09	3.90735E-08	1.63418E-10		
	Dermal Reference Dose	RfD_{der}	mg/kg-d			2.00E-02	5.00E-04		3.00E-02	1.00E-02	4.50E-05	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d			3.66951E-07	1.8513E-07		2.36342E-08	3.83315E-07	0.000868301	5.44727E-08		
	Total Hazard Index	HI	mg/kg-d										1.66E-03	0%
Carcinogenic risk - all routes (detected organics)													5.87E-03	
Carcinogenic risk - all routes (undetected organics)													1.82E-03	
TOTAL CARCINOGENIC RISK - ALL ROUTE		Sum Rt	fraction	3.00E-05		0.00E+00	0.00E+00	5.03E-04	6.13E-05	5.74E-04	3.45E-04	2.92E-06	7.71E-03	
Non-Carcinogenic risk - all routes (detected organics)													4.67E+01	
Non-Carcinogenic risk - all routes (undetected organics)													6.26E+00	
TOTAL NON-CARCINOGENIC HAZARD INDEX - ALL ROUTE		Sum HI	fraction	0		0.553602497	0.110290438	0	0.04966249	0.028926262	3.137132437	0.004924746	5.31E+01	

MEW Site File
3DISC104384

TABLE E.5
RME RISK CALCULATIONS FOR CHILD RESIDENT (HIGH TCE SLOPE FACTOR, WELL D)
MISSOURI ELECTRIC WORKS

Source Medium	Exposure Medium	Exposure Point	Exposure Route	Parameter	Symbol	Units	Non Contaminant-Specific Parameters	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	Total 1,2 Dichloroethene	1,2,4 Trichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chlorophenol	3,3-Dichlorobenzidine	4,6-Dinitro-2-Methyl Phenol	Aroclor-1016	Aroclor-1221
								Chemicals of Potential Concern																
Groundwater	Air	Indoor air	Vapour intrusion - inhalation	POE concentration	C_{a-in}	ug/m3		7.59E-06	9.30E-05	2.27E-03	7.42E-03	4.09E-03	1.92E-04	1.06E-04	8.90E-03	6.16E-03	0.00E+00	0.00E+00	0.00E+00	3.06E-04	0.00E+00	0.00E+00	6.76E-08	0.00E+00
				POE concentration	C_{a-in}	mg/m3		7.59E-09	9.30E-08	2.27E-06	7.42E-06	4.09E-06	1.92E-07	1.06E-07	8.90E-06	6.16E-06	0.00E+00	0.00E+00	0.00E+00	3.06E-07	0.00E+00	0.00E+00	6.76E-11	0.00E+00
				Inhalation rate	IR	m3/hr	0.42																	
				Exposure time	ET	h/d	24																	
				Exposure frequency	EF	d/y	350																	
				Exposure duration	ED	y	6																	
				Body weight	BW	kg	15																	
				Averaging time carcinogens	AT_c	d	25,550																	
				Averaging time non-carcinogens	AT_{nc}	d	2,190																	
				Average intake from inhalation carcinogens	I_c	mg/kg-d		4.19218E-10	5.13666E-09	1.25379E-07	4.09828E-07	2.25902E-07	1.06047E-08	5.85468E-09	4.91573E-07	3.40235E-07	0	0	0	1.69013E-08	0	0	3.73374E-12	0
				Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg		2.03E-01	5.70E-02				9.10E-02			2.20E-02	1.09E-02						4.00E-01	4.00E-01
				Risk	R	fraction		8.51E-11	2.93E-10				9.65E-10			7.49E-09	0.00E+00						1.49E-12	0.00E+00
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from inhalation non-carcinogens	I_n	mg/kg-d		4.89087E-09	5.99277E-08	1.46275E-06	4.78133E-06	2.63553E-06	1.23722E-07	6.83047E-08	5.73501E-06	3.9694E-06	0	0	0	1.97181E-07	0	0	4.35603E-11	0
				Inhalation Reference Dose	RfD_{inh}	mg/kg-d						1.14E-03	1.40E-03	1.14E-03		2.30E-01								
				Hazard Quotient	HQ	mg/kg-d						0.002311867	8.83726E-05	5.99164E-05		1.72583E-05								
				Total Hazard Index	HI	mg/kg-d																		
	Groundwater	Tap Water	Ingestion of tap water	POE concentration	C_w	ug/l		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				POE concentration	C_w	mg/m3		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				Water ingestion rate	IR	l/d	1																	
				Exposure frequency	EF	d/y	350																	
				Exposure duration	ED	y	6																	
				Body weight	BW	kg	15																	
				Averaging time carcinogens	AT_c	d	25,550																	
				Averaging time non-carcinogens	AT_{nc}	d	2,190																	
				Average intake from ingestion carcinogens	I_c	mg/kg-d		5.07342E-07	8.46247E-07	6.6926E-05	6.01096E-05	0.000331616	1.48734E-06	7.94959E-07	0.000241041	0.00027189	1.05786E-06	6.07759E-06	1.45753E-06	1.94301E-05	1.62997E-06	1.04707E-06	1.25479E-06	7.27781E-07
				Ingestion Cancer Slope Factor	CSF_o	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	6.80E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		1.01E-07	4.82E-08				1.35E-07	5.41E-08		6.53E-06	1.16E-08	4.13E-06	9.77E-06		7.33E-07		5.02E-07	2.91E-07
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from ingestion non-carcinogens	I_n	mg/kg-d		5.919E-06	9.87288E-06	0.000780804	0.000701279	0.003868858	1.73523E-05	9.27452E-06	0.002812146	0.003172055	1.23417E-05	7.09052E-05	1.70046E-05	0.000226685	1.90163E-05	1.22158E-05	1.46393E-05	8.49078E-06
				Ingestion Reference Dose	RfD_o	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		9.86499E-05	0.002468219	0.007808037	0.070127854	0.386885845	0.000867616	0.008431382	0.093738204	0.10573516	0.123417352	0.035452603	0.017004546	0.045336986		0.122157991	0.20913242	
				Total Hazard Index	HI	mg/kg-d																		
			Dermal contact with tap water	POE concentration	C_w	ug/l		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				event duration	tevent	hr	1																	
				absorbed dose per event	Doevent	mg/cm2-event		1.71293E-09	2.12216E-09	1.44936E-07	1.47042E-07	1.16844E-05	2.00651E-09	2.10687E-09	5.93365E-06	4.85357E-06	2.15732E-08	1.00576E-08	0	5.85864E-08	1.76154E-08	1.92059E-09	0	5.67678E-08
				Event frequency	EV	events/day	1																	
				Exposure duration	ED	y	6																	
				Exposure frequency	EF	d/y	350																	
				Skin surface area	SA	cm2	6,600																	
				Body weight	BW	kg	15																	
				Averaging time	AT	d/y	25,550																	
				Averaging time non-carcinogens	AT_{nc}	d	2,190																	
				Absorbed dose for carcinogens	DAD_c	mg/kg-d		6.19469E-08	7.67467E-08	5.24152E-06	5.31769E-06	0.000422559	7.25641E-08	7.61936E-08	0.000214587	0.000175526	7.80182E-07	3.63728E-07	0	2.11874E-06	6.37049E-07	6.9457E-08	0	2.05297E-06
				Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	8.00E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		1.24E-08	4.37E-09				6.60E-09	5.18E-09		4.21E-06	8.58E-09	2.91E-07	0.00E+00		2.87E-07		0.00E+00	8.21E-07
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d		7.22714E-07	8.95378E-07	6.1151E-05	6.20397E-05	0.004929851	8.46581E-07	8.88925E-07	0.002503511	0.002047807	9.10213E-06	4.24349E-06	0	2.47186E-05	7.43224E-06	8.10332E-07	0	2.39513E-05
				Dermal Reference Dose	RfD_{der}	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		1.20452E-05	0.000223845	0.00061151	0.006203967	0.492985057	4.2329E-05	0.000808114	0.083450362	0.068260247	0.091021282	0.002121746	0	0.004943729		0.008103318	0	
				Total Hazard Index	HI	mg/kg-d																		
	Air	Indoor Air	Vapors from tap water	Concentration in tap water	C_w	ug/l		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				Concentration in tap water	C_w	mg/m3		0.09259	0.15444	12.214	10.97	60.52	0.27144	0.14508	43.99	49.62	0.19306	1.10916	0.266	3.546	0.29747	0.19109	0.229	0.13282
				Volatilization factor	VF	dimensionless	0.0005	y	Y	Y	Y	Y	Y	Y	Y	Y				Y			Y	
(only calculated for COPC with Henry's Law > 1e-5 atm.m3/mol, those with a 'Y')				POE concentration	C_{a-tap}	mg/m3		0.000046295	0.00007722	0.006107	0.005485	0.03026	0.00013572	0.00007254	0.021995	0.02481	0	0	0	0.001773	0	0	0.0001145	0
				Inhalation rate	IR	m3/hr	0.42																	
				Exposure time	ET	h/d	24																	
				Exposure frequency	EF	d/y	350																	
				Exposure duration	ED	y	6																	
				Body weight	BW	kg	15																	
				Averaging time carcinogens	AT_c	d	25,550																	
				Averaging time non-carcinogens	AT_{nc}	d	2,190																	
				Average intake from inhalation carcinogens	I_c	mg/kg-d		2.55701E-06	4.26508E-06	0.000337307	0.000302952	0.001671347	7.49621E-06	4.00659E-06	0.001214847	0.001370328	0	0	0	9.79279E-05	0	0	6.32416E-06	0

TABLE E.5
RME RISK CALCULATIONS FOR CHILD RESIDENT (HIGH TCE SLOPE FACTOR, WELL D)
MISSOURI ELECTRIC WORKS

Exposure Route	Parameter	Symbol	Units	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260 (Filtered)	Benzene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	bis(2-Chloroethyl) Ether	bis(2-Chloroisopropyl) Ether	Bis (2-ethylhexyl) phthalate	Bromodichloromethane	Carbon Tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroform	Dibenzo(a,h)Anthracene	Dibenzofuran	Hexachloro-1,3-butadiene	Hexachlorobenzene
				Chemicals of Potential Concern																					
Vapour intrusion - Inhalation	POE concentration	C_{a-in}	ug/m3	0.00E+00	3.48E-08	0.00E+00	5.00E-08	2.08E-06	2.17E-03	0.00E+00	0.00E+00	5.21E-08	0.00E+00	4.11E-04	0.00E+00	0.00E+00	1.20E-03	3.04E-05	1.52E+00	9.87E-05	1.13E-02	0.00E+00	3.25E-04	7.48E-07	1.20E-06
	POE concentration	C_{a-in}	mg/m3	0.00E+00	3.48E-11	0.00E+00	5.00E-11	2.08E-09	2.17E-06	0.00E+00	0.00E+00	5.21E-11	0.00E+00	4.11E-07	0.00E+00	0.00E+00	1.20E-06	3.04E-08	1.52E-03	9.87E-08	1.13E-05	0.00E+00	3.25E-07	7.48E-10	1.20E-09
	Inhalation rate	IR	m3/hr																						
	Exposure time	ET	h/d																						
	Exposure frequency	EF	d/y																						
	Exposure duration	ED	y																						
	Body weight	BW	kg																						
	Averaging time carcinogens	AT_c	d																						
	Averaging time non-carcinogens	AT_{nc}	d																						
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	1.92215E-12	0	2.76164E-12	1.14884E-10	1.19855E-07	0	0	2.87763E-12	0	2.27007E-08	0	0	6.62795E-08	1.67908E-09	8.3954E-05	5.45148E-09	6.24132E-07	0	1.79507E-08	4.13142E-11	6.62795E-11
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	2.73E-02	3.08E-01	3.08E+00	3.08E-01	3.08E-01	1.16E+00				5.20E-02			8.10E-02	3.08E-01		7.70E-02	1.61E+00
	Risk	R	fraction	0.00E+00	7.69E-13	0.00E+00	1.10E-12	4.60E-11	3.27E-09	0.00E+00	0.00E+00	8.86E-13	0.00E+00	2.63E-08				8.73E-11			5.06E-08	0.00E+00		3.18E-12	1.07E-10
	Total carcinogenic risk for exposure route	R_t	fraction																						
	Average intake from inhalation non-carcinogens	I_{nc}	mg/kg-d	0	2.24245E-11	0	3.22192E-11	1.34032E-09	1.39831E-06	0	0	3.35724E-11	0	2.64842E-07	0	0	7.7326E-07	1.95893E-08	0.000979463	6.36007E-08	7.28153E-06	0	2.09425E-07	4.81999E-10	7.7326E-10
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d						8.57E-03										1.70E-02						
	Hazard Quotient	HQ	mg/kg-d						0.000163164										0.057615471						
	Total Hazard Index	HI	mg/kg-d																						
Ingestion of tap water	POE concentration	C_w	ug/l	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	POE concentration	C_w	mg/m3	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	Water ingestion rate	IR	l/d																						
	Exposure frequency	EF	d/y																						
	Exposure duration	ED	y																						
	Body weight	BW	kg																						
	Averaging time carcinogens	AT_c	d																						
	Averaging time non-carcinogens	AT_{nc}	d																						
	Average intake from ingestion carcinogens	I_c	mg/kg-d	8.78356E-07	5.01918E-07	3.26247E-07	5.5211E-07	2.25863E-05	0.000414959	3.56362E-06	3.31266E-06	5.05307E-06	2.91123E-06	3.07726E-05	4.46203E-06	0.000602301	1.28219E-05	4.5337E-07	0.015896877	1.0514E-06	6.6474E-05	2.70329E-06	4.14082E-06	3.73929E-06	3.71419E-06
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	5.50E-02	7.30E-01	7.30E+00	7.30E-01	7.30E-02	1.10E+00		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
	Risk	R	fraction	3.51E-07	2.01E-07	1.30E-07	2.21E-07	9.03E-06	2.28E-05	2.60E-06	2.42E-05	3.69E-06	2.13E-07	3.38E-05		8.43E-06	7.95E-07	5.89E-08		8.83E-08		1.97E-05		2.92E-07	5.94E-06
	Total carcinogenic risk for exposure route	R_t	fraction																						
	Average intake from ingestion non-carcinogens	I_{nc}	mg/kg-d	1.02475E-05	5.85571E-06	3.80621E-06	6.44128E-06	0.000263507	0.004841187	4.15755E-05	3.86477E-05	5.89525E-05	3.39644E-05	0.000359014	5.2057E-05	0.007026849	0.000149589	5.28932E-06	0.185463542	1.22663E-05	0.000777863	3.15384E-05	4.83096E-05	4.3625E-05	4.33322E-05
	Ingestion Reference Dose	RfD_o	mg/kg-d				2.00E-05		4.00E-03						4.00E-02	2.00E-02	2.00E-02	7.00E-04	2.00E-02	2.00E-02	1.00E-02		4.00E-03	2.00E-04	8.00E-04
	Hazard Quotient	HQ	mg/kg-d				0.322063927		1.210296804						0.001301425	0.351342466	0.007479452	0.007556164	9.273178082	0.000613315	0.077786301		0.012077397	0.218125114	0.054165297
	Total Hazard Index	HI	mg/kg-d																						
Dermal contact with tap water	POE concentration	C_w	ug/l	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	event duration	t_{event}	hr																						
	absorbed dose per event	DA_{event}	mg/cm2-even	6.85129E-08	2.99626E-07	2.08921E-07	5.6124E-07	0.000143389	1.76209E-06	1.20373E-06	1.91842E-06	2.96952E-06	1.6864E-06	2.26685E-08	1.1527E-07	2.47184E-05	2.80879E-08	3.28754E-09	0.000152749	2.14049E-09	1.6194E-07	2.4313E-06	1.98459E-07	2.41637E-07	4.62517E-07
	Event frequency	EV	events/day																						
	Exposure duration	ED	y																						
	Exposure frequency	EF	d/y																						
	Skin surface area	SA	cm2																						
	Body weight	BW	kg																						
	Averaging time	AT	d/y																						
	Averaging time non-carcinogens	AT_{nc}	d																						
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	2.47773E-06	1.08358E-05	7.5555E-06	2.02969E-05	0.00518558	6.37248E-05	4.35323E-05	6.93786E-05	0.000107391	6.09875E-05	8.19794E-07	4.16866E-06	0.000893926	1.01578E-06	1.18892E-07	0.005524088	7.74093E-08	5.85645E-06	8.79266E-05	7.17714E-06	8.73864E-06	1.67266E-05
	Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	5.50E-02	2.35E-01	2.35E+00	2.30E-02	7.30E-02	1.10E+00		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
	Risk	R	fraction	9.91E-07	4.33E-06	3.02E-06	8.12E-06	2.07E-03	3.50E-06	1.02E-05	1.63E-04	2.47E-06	4.45E-06	9.02E-07		1.25E-05	6.30E-08	1.55E-08		6.50E-09		6.42E-04		6.82E-07	2.68E-05
	Total carcinogenic risk for exposure route	R_t	fraction																						
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	2.89068E-05	0.000126418	8.81475E-05	0.000236797	0.060498432	0.000743456	0.000507877	0.000809417	0.001252895	0.00071152	9.56426E-06	4.86343E-05	0.010429134	1.18508E-05	1.38707E-06	0.064447698	9.03109E-07	6.83253E-05	0.00102581	8.37333E-05	0.000101951	0.000195144
	Dermal Reference Dose	RfD_{der}	mg/kg-d				2.00E-05		4.00E-03						4.00E-02	3.80E-03	2.00E-02	7.00E-04	6.20E-03	2.00E-02	2.00E-03		4.00E-03	2.00E-04	8.00E-04
	Hazard Quotient	HQ	mg/kg-d				11.83985998		0.185863921						0.001215858	2.744508883	0.000592539	0.001981533	10.39479003	4.51554E-05	0.034162651		0.020933313	0.509753746	0.24392995
	Total Hazard Index	HI	mg/kg-d																						
Vapors from tap water	Concentration in tap water	C_w	ug/l	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49336	0.7557	0.68242	0.67784
	Concentration in tap water	C_w	mg/m3	0.1603	0.0916	0.05954	0.10076	4.122	75.73	0.65036	0.60456	0.922185	0.5313	5.616	0.81432	109.92	2.34	0.08274	2901.18	0.19188	12.168	0.49335	0.7557	0.68242	0.67784
	Volatilization factor	VF	dimensionless		y		y	y	y			y		y			y	y	y	y	y		y	y	y
not, those with a "Y")	POE concentration	C_{a-tap}	mg/m3	0	0.0000458	0	0.00005038	0.002061	0.037865	0	0	0.000461093	0	0.002808	0	0	0.00117	0.00004137	1.45059	0.00009594	0.006084	0	0.00037785	0.00034121	0.00033892
	Inhalation rate	IR	m3/hr																						
	Exposure time	ET	h/d																						
	Exposure frequency	EF	d/y																						
	Exposure duration	ED	y																						
	Body weight	BW	kg																						
	Averaging time carcinogens	AT_c	d																						
	Averaging time non-carcinogens	AT_{nc}	d																						
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	2.52967E-06	0	2.78263E-06	0.000113835	0.002091393	0	0	2.54675E-05	0	0.000155094	0	0	6.46225E-05	2.28498E-06	0.080120259	5.29904E-06	0.000336037	0	2.08697E-05	1.8846E-05	1.87195E-05

MEW Site File
3DISC104386

TABLE E.5
RME RISK CALCULATIONS FOR CHILD RESIDENT (HIGH TCE SLOPE FACTOR, WELL D)
MISSOURI ELECTRIC WORKS

				Chemicals of Potential Concern										
Exposure Route	Parameter	Symbol	Units	Indeno(1,2,3-cd)Pyrene	2-methylnaphthalene	Naphthalene	Nitrobenzene	Nitrosodi-n-propylamine	Pentachlorophenol	Tetrachloroethene	Trichloroethene	Vinyl Chloride	Total	% Contribution
Vapour intrusion - Inhalation	POE concentration	C_{a-in}	ug/m3	0.00E+00	2.19E-05	2.75E-04	6.87E-06	0.00E+00	0.00E+00	1.31E-03	2.50E-02	9.36E-04		
	POE concentration	C_{a-in}	mg/m3	0.00E+00	2.19E-08	2.75E-07	6.87E-09	0.00E+00	0.00E+00	1.31E-06	2.50E-05	9.36E-07		
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	ATn_c	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	1.2096E-09	1.5189E-08	3.7945E-10	0	0	7.23551E-08	1.38082E-06	5.1698E-08		
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	3.08E-01						2.10E+00	4.00E-01	3.00E-02		
	Risk	R	fraction	0.00E+00						1.52E-07	5.52E-07	1.55E-09		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]	0%
	Average intake from inhalation non-carcinogens	I_n	mg/kg-d	0	1.4112E-08	1.77205E-07	4.42692E-09	0	0	8.44142E-07	1.61096E-05	6.03143E-07		
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d			8.57E-04	5.71E-04			1.40E-01	1.14E-02	2.86E-02		
	Hazard Quotient	HQ	mg/kg-d			0.000206774	7.75292E-06			6.02989E-06	0.001413122	2.10889E-05		
	Total Hazard Index	HI	mg/kg-d										[redacted]	0%
Ingestion of tap water	POE concentration	C_w	ug/l	0.5313	0.2837	3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	POE concentration	C_w	mg/m3	0.5313	0.2837	3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	Water ingestion rate	IR	l/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_a	d											
	Averaging time non-carcinogens	ATn_a	d											
	Average intake from ingestion carcinogens	I_c	mg/kg-d	2.91123E-06	1.55452E-06	1.87825E-05	2.02937E-06	4.1543E-05	2.26867E-05	2.95342E-05	8.35616E-05	0.000001872		
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	7.30E-01				7.00E+00	1.20E-01	5.40E-01	4.00E-01	7.20E-01		
	Risk	R	fraction	2.13E-06				2.91E-04	2.72E-06	1.59E-05	3.34E-05	1.35E-06		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]	11%
	Average intake from ingestion non-carcinogens	I_n	mg/kg-d	3.39644E-05	1.81361E-05	0.000219129	2.3676E-05	0.000484668	0.000264678	0.000344566	0.000974886	0.00002184		
	Ingestion Reference Dose	RfD_o	mg/kg-d		4.00E-03	2.00E-02	5.00E-04		3.00E-02	1.00E-02	3.00E-04	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d		0.004534018	0.010956438	0.047351963		0.0088226	0.034456621	3.249619482	0.00728		
	Total Hazard Index	HI	mg/kg-d										[redacted]	13%
Dermal contact with tap water	POE concentration	C_w	ug/l	0.5313	0.2837	3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	event duration	tevent	hr											
	absorbed dose per event	Daevent	mg/cm2-even	1.78289E-06	0	3.29882E-07	3.98612E-09	3.69993E-08	7.32983E-06	4.7412E-07	3.73936E-07	2.80865E-09		
	Event frequency	EV	events/day											
	Exposure duration	ED	y											
	Exposure frequency	EF	d/y											
	Skin surface area	SA	cm2											
	Body weight	BW	kg											
	Averaging time	AT	d/y											
	Averaging time non-carcinogens	ATn_c	d											
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	6.4477E-05	0	1.193E-05	1.44156E-07	1.33806E-06	0.000265079	1.71463E-05	1.35232E-05	1.01573E-07		
	Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg	2.30E-01				1.80E+00	1.20E-01	5.40E-01	6.00E-02	7.20E-01		
	Risk	R	fraction	1.48E-05				2.41E-06	3.18E-05	9.26E-06	8.11E-07	7.31E-08		
	Total carcinogenic risk for exposure route	R_t	fraction										3.02E-03	69%
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	0.000752231	0	0.000139183	1.68181E-06	1.56107E-05	0.003092585	0.00020004	0.00015777	1.18502E-06		
	Dermal Reference Dose	RfD_{der}	mg/kg-d		4.00E-03	2.00E-02	5.00E-04		3.00E-02	1.00E-02	4.50E-05	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d		0	0.006959146	0.003363629		0.103086176	0.020003964	3.506007297	0.000395006		
	Total Hazard Index	HI	mg/kg-d										3.04E+01	25%
Vapors from tap water	Concentration in tap water	C_w	ug/l	0.5313	0.2837	3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	Concentration in tap water	C_w	mg/m3	0.5313	0.2837	3.4278	0.37036	7.5816	4.14032	5.39	15.25	0.34164		
	Volatilization factor	VF	dimensionless		Y	Y	Y			Y	Y	Y		
(incl. those with a 'Y')	POE concentration	C_{w-vap}	mg/m3	0	0.00014185	0.0017139	0.00018518	0	0	0.002695	0.007625	0.00017082		
	Inhalation rate	IR	m3/hr											
	Exposure time	ET	h/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	ATn_c	d											
	Average intake from inhalation carcinogens	I_c	mg/kg-d	0	7.83478E-06	9.46636E-05	1.0228E-05	0	0	0.000148853	0.000421151	9.43488E-06		

TABLE E.5
RME RISK CALCULATIONS FOR CHILD RESIDENT (HIGH TCE SLOPE FACTOR, WELL D)
MISSOURI ELECTRIC WORKS

Source Medium	Exposure Medium	Exposure Point	Exposure Route	Parameter	Symbol	Units	Non Contaminant-Specific Parameters	1,1,2,2-Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	Total 1,2 Dichloroethene	1,2,4 Trichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2,4,6-Trichlorophenol	2,4-Dinitrotoluene	2,6-Dinitrotoluene	2-Chlorophenol	3,3-Dichlorobenzidine	4,6-Dinitro-2-Methyl Phenol	Aroclor-1016	Aroclor-1221
								Chemicals of Potential Concern																
				Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg		2.03E-01	5.70E-02				9.10E-02			2.20E-02	1.09E-02						4.00E-01	4.00E-01
				Risk	R	fraction		5.19E-07	2.43E-07				6.82E-07			3.01E-05	0.00E+00						2.53E-06	0.00E+00
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from inhalation non-carcinogens	I_n	mg/kg-d		2.98317E-05	4.97593E-05	0.00393525	0.003534444	0.019499047	8.74557E-05	4.67436E-05	0.014173216	0.015987156	0	0	0	0.001142492	0	0	7.37819E-05	0
				Inhalation Reference Dose	RfD_{inh}	mg/kg-d						1.14E-03	1.40E-03	1.14E-03		2.30E-01								
				Hazard Quotient	HQ	mg/kg-d						17.10442682	0.062468384	0.041003143		0.069509375								
				Total Hazard Index	HI	mg/kg-d																		
	Surface Water	Creek	Incidental ingestion of creek water	POE concentration	C_w	ug/l		3.87145E-05	0.00014692	0.005107025	0.168484251	0.003415705	0.000258223	0.000138016	0.277239592	0.332753253	8.07239E-05	0.001055151	0.0001112	0.001482685	0.000124381	7.99002E-05	4.276E-07	2.47989E-07
				POE concentration	C_w	mg/m3		3.87145E-05	0.00014692	0.005107025	0.168484251	0.003415705	0.000258223	0.000138016	0.277239592	0.332753253	8.07239E-05	0.001055151	0.0001112	0.001482685	0.000124381	7.99002E-05	4.276E-07	2.47989E-07
				Water ingestion rate	IR	l/d	0.05																	
				Exposure frequency	EF	d/y	52																	
				Exposure duration	ED	y	6																	
				Body weight	BW	kg	15																	
				Averaging time carcinogens	AT_c	d	25,550																	
				Averaging time non-carcinogens	AT_{nc}	d	2,190																	
				Average intake from ingestion carcinogens	I_g	mg/kg-d		1.57586E-12	5.9803E-12	2.07879E-10	6.85807E-09	1.39035E-10	1.05108E-11	5.61785E-12	1.12849E-08	1.35446E-08	3.28583E-12	4.29494E-11	4.52634E-12	6.03519E-11	5.06286E-12	3.2523E-12	1.74052E-14	1.00943E-14
				Ingestion Cancer Slope Factor	CSF_o	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	6.80E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		3.15E-13	3.41E-13				9.56E-13	3.82E-13		3.25E-10	3.61E-14	2.92E-11	3.03E-11		2.28E-12		6.96E-15	4.04E-15
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Average intake from ingestion non-carcinogens	I_g	mg/kg-d		1.8385E-11	6.97701E-11	2.42525E-09	8.00108E-08	1.62207E-09	1.22626E-10	6.55416E-11	1.31657E-07	1.5802E-07	3.83347E-11	5.01076E-10	5.28073E-11	7.04106E-10	5.90667E-11	3.79435E-11	2.03061E-13	1.17766E-13
				Ingestion Reference Dose	RfD_o	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		3.06416E-10	1.74425E-08	2.42525E-08	8.00108E-06	1.62207E-07	6.13131E-09	5.95833E-08	4.38857E-06	5.26733E-06	3.83347E-07	2.50538E-07	5.28073E-08	1.40821E-07		3.79435E-07	2.90087E-09	
				Total Hazard Index	HI	mg/kg-d																		
			Dermal contact with creek water	POE concentration	C_w	ug/l		3.87145E-05	0.00014692	0.005107025	0.168484251	0.003415705	0.000258223	0.000138016	0.277239592	0.332753253	8.07239E-05	0.001055151	0.0001112	0.001482685	0.000124381	7.99002E-05	4.276E-07	2.47989E-07
				event duration	tevent	hr	2																	
				absorbed dose per event	Daevent	mg/cm2-event		1.01289E-12	2.99941E-12	9.41817E-11	3.52119E-09	9.32615E-10	2.97547E-12	3.08949E-12	5.39677E-08	4.70013E-08	1.27568E-11	1.3531E-11	0	3.66143E-11	1.04164E-11	1.13569E-12	0	1.49895E-13
				Event frequency	EV	events/day	1																	
				Exposure duration	ED	y	6																	
				Exposure frequency	EF	d/y	52																	
				Skin surface area	SA	cm2	6,600																	
				Body weight	BW	kg	15																	
				Averaging time	AT	d/y	25,550																	
				Averaging time non-carcinogens	AT_{nc}	d	2,190																	
				Absorbed dose for carcinogens	DAD_c	mg/kg-d		5.44227E-12	1.61158E-11	5.06038E-10	1.89193E-08	5.01093E-09	1.59872E-11	1.65998E-11	2.89968E-07	2.52537E-07	6.8542E-11	7.27022E-11	0	1.96728E-10	5.59672E-11	6.10206E-12	0	8.05383E-13
				Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg		2.00E-01	5.70E-02				9.10E-02	6.80E-02		2.40E-02	1.10E-02	8.00E-01	6.70E+00		4.50E-01		4.00E-01	4.00E-01
				Risk	R	fraction		1.09E-12	9.19E-13				1.45E-12	1.13E-12		6.06E-09	7.54E-13	5.32E-11	0.00E+00		2.52E-11		0.00E+00	3.22E-13
				Total carcinogenic risk for exposure route	R_t	fraction																		
				Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d		6.34932E-11	1.88018E-10	5.90377E-09	2.20725E-07	5.84609E-08	1.86517E-10	1.93665E-10	3.38296E-06	2.94627E-06	7.99656E-10	8.48192E-10	0	2.29516E-09	6.52951E-10	7.11907E-11	0	9.39614E-12
				Dermal Reference Dose	RfD_{der}	mg/kg-d		6.00E-02	4.00E-03	1.00E-01	1.00E-02	1.00E-02	2.00E-02	1.10E-03	3.00E-02	3.00E-02	1.00E-04	2.00E-03	1.00E-03	5.00E-03		1.00E-04	7.00E-05	
				Hazard Quotient	HQ	mg/kg-d		1.05822E-09	4.70044E-08	5.90377E-08	2.20725E-05	5.84609E-06	9.32587E-09	1.76059E-07	0.000112765	9.8209E-05	7.99656E-06	4.24096E-07	0	4.59033E-07		7.11907E-07	0	
				Total Hazard Index	HI	mg/kg-d																		
			Carcinogenic risk - all routes (detected organics)																					
			Carcinogenic risk - all routes (undetected organics)																					
			TOTAL CARCINOGENIC RISK - ALL ROUTES		Sum Rt	fraction		6.33E-07	2.96E-07	0.00E+00	0.00E+00	0.00E+00	8.25E-07	5.92E-08	0.00E+00	4.09E-05	2.02E-08	4.42E-06	9.77E-06	0.00E+00	1.02E-06	0.00E+00	3.03E-06	1.11E-06
			Non-Carcinogenic risk - all routes (detected organics)																					
			Non-Carcinogenic risk - all routes (undetected organics)																					
			TOTAL NON-CARCINOGENIC HAZARD INDEX - ALL ROUTES		Sum HI	fraction		0.000110697	0.002692128	0.00841963	0.076361895	17.9866156	0.063466717	0.050302792	0.177305719	0.243625516	0.214447013	0.037575024	0.017004619	0.050281315	0	0.1302624	0.209132423	0

Notes:
1- ug/l = micrograms per Liter
2- ug/m3 = micrograms per cubic meter
3- h/d = hours per day
4- l/d = liters per day
5- d/y = days per year
6- y = year
7- kg = kilogram
8- d = day
9- hr = hour
10- mg/kg-d = milligrams per kilogram per day
11- kg-d/mg = kilograms per day per milligram
12- cm2 = square centimeter
13- m3/hr = cubic meter per hour
14- mg/m3 = milligrams per cubic meter
15- mg/cm2-event = milligrams per square centimeter per event
16- mg/cm3-event = milligrams per cubic centimeter per event

TABLE E.5
RME RISK CALCULATIONS FOR CHILD RESIDENT (HIGH TCE SLOPE FACTOR, WELL D)
MISSOURI ELECTRIC WORKS

Chemicals of Potential Concern

Exposure Route	Parameter	Symbol	Units	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260 (Filtered)	Benzene
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	2.73E-02
	Risk	R	fraction	0.00E+00	1.01E-06	0.00E+00	1.11E-06	4.55E-05	5.71E-05
	Total carcinogenic risk for exposure route	R_t	fraction						
	Average intake from inhalation non-carcinogens	I_n	mg/kg-d	0	2.95128E-05	0	3.2464E-05	0.001328075	0.024399584
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d						8.57E-03
	Hazard Quotient	HQ	mg/kg-d						2.847092598
	Total Hazard Index	HI	mg/kg-d						
Incidental ingestion of creek water	POE concentration	C_w	ug/l	2.99297E-07	1.71027E-07	1.11168E-07	1.8813E-07	7.69621E-06	0.003648704
	POE concentration	C_w	mg/m3	2.99297E-07	1.71027E-07	1.11168E-07	1.8813E-07	7.69621E-06	0.003648704
	Water ingestion rate	IR	l/d						
	Exposure frequency	EF	d/y						
	Exposure duration	ED	y						
	Body weight	BW	kg						
	Averaging time carcinogens	AT_c	d						
	Averaging time non-carcinogens	ATn_c	d						
	Average intake from ingestion carcinogens	I_n	mg/kg-d	1.21827E-14	6.96157E-15	4.52502E-15	7.65772E-15	3.1327E-13	1.48519E-10
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	5.50E-02
	Risk	R	fraction	4.87E-15	2.78E-15	1.81E-15	3.06E-15	1.25E-13	8.17E-12
	Total carcinogenic risk for exposure route	R_t	fraction						
	Average intake from ingestion non-carcinogens	I_n	mg/kg-d	1.42132E-13	8.12183E-14	5.27919E-14	8.93401E-14	3.65482E-12	1.73272E-09
	Ingestion Reference Dose	RfD_o	mg/kg-d				2.00E-05		4.00E-03
	Hazard Quotient	HQ	mg/kg-d				4.467E-09		4.33179E-07
	Total Hazard Index	HI	mg/kg-d						
Dermal contact with creek water	POE concentration	C_w	ug/l	2.99297E-07	1.71027E-07	1.11168E-07	1.8813E-07	7.69621E-06	0.003648704
	event duration	tevent	hr						
	absorbed dose per event	Daevent	mg/cm2-even	1.80907E-13	7.91158E-13	5.51653E-13	1.48195E-12	3.78617E-10	1.36534E-10
	Event frequency	EV	events/day						
	Exposure duration	ED	y						
	Exposure frequency	EF	d/y						
	Skin surface area	SA	cm2						
	Body weight	BW	kg						
	Averaging time	AT	d/y						
	Averaging time non-carcinogens	ATn_c	d						
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	9.72014E-13	4.25089E-12	2.96403E-12	7.96249E-12	2.03431E-09	7.33597E-10
	Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg	4.00E-01	4.00E-01	4.00E-01	4.00E-01	4.00E-01	5.50E-02
	Risk	R	fraction	3.89E-13	1.70E-12	1.19E-12	3.18E-12	8.14E-10	4.03E-11
	Total carcinogenic risk for exposure route	R_t	fraction						
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	1.13402E-11	4.95937E-11	3.45803E-11	9.28958E-11	2.37336E-08	8.55864E-09
	Dermal Reference Dose	RfD_{der}	mg/kg-d				2.00E-05		4.00E-03
	Hazard Quotient	HQ	mg/kg-d				4.64479E-06		2.13966E-06
	Total Hazard Index	HI	mg/kg-d						
Carcinogenic risk - all routes (detected organics)									
Carcinogenic risk - all routes (undetected organics)									
TOTAL CARCINOGENIC RISK - ALL ROUTES		Sum Rt	fraction	1.34E-06	5.55E-06	3.15E-06	9.45E-06	2.13E-03	8.34E-05
Non-Carcinogenic risk - all routes (detected organics)									
Non-Carcinogenic risk - all routes (undetected organics)									
TOTAL NON-CARCINOGENIC HAZARD INDEX - ALL ROUTES		Sum HI	fraction	0	0	0	12.16192855	0	4.243419059

Parameter	Symbol	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	bis(2-Chloroethyl) Ether	bis(2-Chloroisopropyl) Ether	Bis (2-ethylhexyl phthalate)	Bromodichloromethane	Carbon Tetrachloride	Chlorobenzene	Chlorodibromomethane	Chloroform	Dibenzo(a,h)Anthracene	Dibenzofuran	Hexachloro-1,3-butadiene	Hexachlorobenzene
Inhalation Cancer Slope Factor	CSF_{inh}	3.08E-01	3.08E+00	3.08E-01	3.08E-01	1.16E+00				5.20E-02			8.10E-02	3.08E-01		7.70E-02	1.61E+00
Risk	R	0.00E+00	0.00E+00	7.84E-06	0.00E+00	1.80E-04				1.19E-07			2.72E-05	0.00E+00		1.45E-06	3.01E-05
Total carcinogenic risk for exposure route	R_t																
Average intake from inhalation non-carcinogens	I_n	0	0	0.00029712	0	0.001809429	0	0	0.000753929	2.66581E-05	0.934736351	6.18222E-05	0.00392043	0	0.00024348	0.00021987	0.000218394
Inhalation Reference Dose	RfD_{inh}										1.70E-02						
Hazard Quotient	HQ										54.98449122						
Total Hazard Index	HI																
POE concentration	C_w	1.21429E-06	1.12878E-06	9.13887E-09	5.26519E-09	0.005342537	0.000774668	0.000205232	0.002226	3.4596E-05	1.35956262	0.000182537	0.011575497	4.88911E-09	1.41097E-06	1.27415E-06	4.00642E-06
POE concentration	C_w	1.21429E-06	1.12878E-06	9.13887E-09	5.26519E-09	0.005342537	0.000774668	0.000205232	0.002226	3.4596E-05	1.35956262	0.000182537	0.011575497	4.88911E-09	1.41097E-06	1.27415E-06	4.00642E-06
Water ingestion rate	IR																
Exposure frequency	EF																
Exposure duration	ED																
Body weight	BW																
Averaging time carcinogens	AT_c																
Averaging time non-carcinogens	ATn_c																
Average intake from ingestion carcinogens	I_n	4.94271E-14	4.59463E-14	3.71993E-16	2.14317E-16	2.17465E-10	3.15325E-11	8.35388E-12	9.06082E-11	1.40821E-12	5.53403E-08	7.43006E-12	4.71175E-10	1.99009E-16	5.74329E-14	5.18637E-14	1.63079E-13
Ingestion Cancer Slope Factor	CSF_o	7.30E-01	7.30E+00	7.30E-01	7.30E-02	1.10E+00		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
Risk	R	3.61E-14	3.35E-13	2.72E-16	1.56E-17	2.39E-10		1.17E-13	5.62E-12	1.83E-13		6.24E-13		1.45E-15		4.05E-15	2.61E-13
Total carcinogenic risk for exposure route	R_t																
Average intake from ingestion non-carcinogens	I_n	5.7665E-13	5.36041E-13	4.33992E-15	2.50037E-15	2.5371E-09	3.67879E-10	9.74619E-11	1.0571E-09	1.64291E-11	6.45637E-07	8.66841E-11	5.49704E-09	2.32177E-15	6.70051E-13	6.05076E-13	1.90259E-12
Ingestion Reference Dose	RfD_o						4.00E-02	2.00E-02	2.00E-02	7.00E-04	2.00E-02	2.00E-02	1.00E-02		4.00E-03	2.00E-04	8.00E-04
Hazard Quotient	HQ						9.19697E-09	4.8731E-09	5.28548E-08	2.34702E-08	3.22819E-05	4.3342E-09	5.49704E-07		1.67513E-10	3.02538E-09	2.37824E-09
Total Hazard Index	HI																
POE concentration	C_w	1.21429E-06	1.12878E-06	9.13887E-09	5.26519E-09	0.005342537	0.000774668	0.000205232	0.002226	3.4596E-05	1.35956262	0.000182537	0.011575497	4.88911E-09	1.41097E-06	1.27415E-06	4.00642E-06
event duration	tevent																
absorbed dose per event	Daevent	3.17844E-12	5.06557E-12	4.16175E-14	2.36346E-14	3.17633E-11	1.55078E-10	6.52686E-11	3.77871E-11	1.99165E-12	1.07752E-07	2.8797E-12	2.34503E-10	3.40744E-14	5.24028E-13	6.38038E-13	3.86609E-12
Event frequency	EV																
Exposure duration	ED																
Exposure frequency	EF																
Skin surface area	SA																
Body weight	BW																
Averaging time	AT																
Averaging time non-carcinogens	ATn_c																
Absorbed dose for carcinogens	DAD_c	1.70778E-11	2.72173E-11	2.23611E-13	1.26989E-13	1.70664E-10	8.33234E-10	3.50688E-10	2.0303E-10	1.07011E-11	5.78949E-07	1.54726E-11	1.25998E-09	1.83082E-13	2.8156E-12	3.42817E-12	2.07725E-11
Dermal Cancer Slope Factor	CSF_{der}	2.35E-01	2.35E+00	2.30E-02	7.30E-02	1.10E+00		1.40E-02	6.20E-02	1.30E-01		8.40E-02		7.30E+00		7.80E-02	1.60E+00
Risk	R	4.01E-12	6.40E-11	5.14E-15	9.27E-15	1.88E-10		4.91E-12	1.26E-11	1.39E-12		1.30E-12		1.34E-12		2.67E-13	3.32E-11
Total carcinogenic risk for exposure route	R_t																
Absorbed dose for non-carcinogens	DAD_{nc}	1.9924E-10	3.17535E-10	2.60879E-12	1.48154E-12	1.99108E-09	9.72106E-09	4.09136E-09	2.36868E-09	1.24846E-10	6.7544E-06	1.80514E-10	1.46998E-08	2.13595E-12	3.28486E-11	3.99954E-11	2.42345E-10
Dermal Reference Dose	RfD_{der}						4.00E-02	3.80E-03	2.00E-02	7.00E-04	6.20E-03	2.00E-02	2.00E-03		4.00E-03	2.00E-04	8.00E-04
Hazard Quotient	HQ						2.43026E-07	1.07667E-06	1.18434E-07	1.78352E-07	0.00108942	9.0257E-09	7.3499E-06		8.21216E-09	1.99977E-07	3.02932E-07
Total Hazard Index	HI																
Carcinogenic risk - all routes (detected organics)																	
Carcinogenic risk - all routes (undetected organics)																	
TOTAL CARCINOGENIC RISK - ALL ROUTES	Sum Rt	1.28E-05	1.87E-04	1.40E-05	4.66E-06	2.15E-04	0.00E+00	2.09E-05	8.58E-07	1.93E-07	0.00E+00	9.48E-08	2.73E-05	6.62E-04	0.00E+00	2.42E-06	6.28E-05
Non-Carcinogenic risk - all routes (detected organics)																	
Non-Carcinogenic risk - all routes (undetected organics)																	
TOTAL NON-CARCINOGENIC HAZARD INDEX - ALL ROUTES	Sum HI	0	0	0	0	0	0.002517535	3.09585243	0.008072162	0.009537899	74.7111965	0.000658484	0.111956852	0	0.033010719	0.727879063	0.298095552

TABLE E.5
RME RISK CALCULATIONS FOR CHILD RESIDENT (HIGH TCE SLOPE FACTOR, WELL D)
MISSOURI ELECTRIC WORKS

				Chemicals of Potential Concern										
Exposure Route	Parameter	Symbol	Units	Indeno(1,2,3-cd)Pyrene	2-methylnapthalene	Naphthalene	Nitrobenzene	Nitrosodi-n-propylamine	Pentachlorophenol	Tetrachloroethene	Trichloroethene	Vinyl Chloride	Total	% Contribution
	Inhalation Cancer Slope Factor	CSF_{inh}	kg-d/mg	3.08E-01						2.10E+00	4.00E-01	3.00E-02		
	Risk	R	fraction	0.00E+00						3.13E-04	1.68E-04	2.83E-07		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]	20%
	Average intake from inhalation non-carcinogens	I_a	mg/kg-d	0	9.14058E-05	0.001104409	0.000119327	0	0	0.001736614	0.004913425	0.000110074		
	Inhalation Reference Dose	RfD_{inh}	mg/kg-d			8.57E-04	5.71E-04			1.40E-01	1.14E-02	2.86E-02		
	Hazard Quotient	HQ	mg/kg-d			1.288691933	0.208978893			0.012404384	0.431002163	0.003848727		
	Total Hazard Index	HI	mg/kg-d										[redacted]	62%
Incidental ingestion of creek water	POE concentration	C_w	ug/l	5.26519E-09	0.0001186	0.001433262	0.000154858	0.007212425	7.73042E-06	0.000841116	0.029336582	0.000325004		
	POE concentration	C_w	mg/m3	5.26519E-09	0.0001186	0.001433262	0.000154858	0.007212425	7.73042E-06	0.000841116	0.029336582	0.000325004		
	Water ingestion rate	IR	l/d											
	Exposure frequency	EF	d/y											
	Exposure duration	ED	y											
	Body weight	BW	kg											
	Averaging time carcinogens	AT_c	d											
	Averaging time non-carcinogens	ATn_c	d											
	Average intake from ingestion carcinogens	I_g	mg/kg-d	2.14317E-16	4.82755E-12	5.83402E-11	6.30342E-12	2.93578E-10	3.14663E-13	3.42372E-11	1.19413E-09	1.32291E-11		
	Ingestion Cancer Slope Factor	CSF_o	kg-d/mg	7.30E-01				7.00E+00	1.20E-01	5.40E-01	4.00E-01	7.20E-01		
	Risk	R	fraction	1.56E-16				2.06E-09	3.78E-14	1.85E-11	4.78E-10	9.52E-12		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]	0%
	Average intake from ingestion non-carcinogens	I_g	mg/kg-d	2.50037E-15	5.63215E-11	6.80636E-10	7.354E-11	3.42508E-09	3.67107E-12	3.99434E-10	1.39315E-08	1.5434E-10		
	Ingestion Reference Dose	RfD_o	mg/kg-d		4.00E-03	2.00E-02	5.00E-04		3.00E-02	1.00E-02	3.00E-04	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d		1.40804E-08	3.40318E-08	1.4708E-07		1.22369E-10	3.99434E-08	4.64384E-05	5.14467E-08		
	Total Hazard Index	HI	mg/kg-d										[redacted]	0%
Dermal contact with creek water	POE concentration	C_w	ug/l	5.26519E-09	0.0001186	0.001433262	0.000154858	0.007212425	7.73042E-06	0.000841116	0.029336582	0.000325004		
	event duration	tevent	hr											
	absorbed dose per event	Daevent	mg/cm2-even	2.49869E-14	0	2.00333E-10	2.52675E-12	5.27912E-11	1.93543E-11	1.04633E-10	1.06659E-09	4.46083E-12		
	Event frequency	EV	events/day											
	Exposure duration	ED	y											
	Exposure frequency	EF	d/y											
	Skin surface area	SA	cm2											
	Body weight	BW	kg											
	Averaging time	AT	d/y											
	Averaging time non-carcinogens	ATn_c	d											
	Absorbed dose for carcinogens	DAD_c	mg/kg-d	1.34255E-13	0	1.07639E-09	1.35762E-11	2.83647E-10	1.03991E-10	5.62195E-10	5.73079E-09	2.3968E-11		
	Dermal Cancer Slope Factor	CSF_{der}	kg-d/mg	2.30E-01				1.80E+00	1.20E-01	5.40E-01	6.00E-02	7.20E-01		
	Risk	R	fraction	3.09E-14				5.11E-10	1.25E-11	3.04E-10	3.44E-10	1.73E-11		
	Total carcinogenic risk for exposure route	R_t	fraction										[redacted]	0%
	Absorbed dose for non-carcinogens	DAD_{nc}	mg/kg-d	1.5663E-12	0	1.25579E-08	1.58389E-10	3.30921E-09	1.21322E-09	6.55894E-09	6.68592E-08	2.79627E-10		
	Dermal Reference Dose	RfD_{der}	mg/kg-d		4.00E-03	2.00E-02	5.00E-04		3.00E-02	1.00E-02	4.50E-05	3.00E-03		
	Hazard Quotient	HQ	mg/kg-d		0	6.27894E-07	3.16778E-07		4.04408E-08	6.55894E-07	0.001485759	9.32089E-08		
	Total Hazard Index	HI	mg/kg-d										[redacted]	0%
Carcinogenic risk - all routes (detected organics)													3.35E-03	
Carcinogenic risk - all routes (undetected organics)													1.03E-03	
TOTAL CARCINOGENIC RISK - ALL ROUTES		Sum Rt	fraction	1.70E-05	0.00E+00	0.00E+00	0.00E+00	2.93E-04	3.45E-05	3.38E-04	2.03E-04	1.71E-06	4.39E-03	
Non-Carcinogenic risk - all routes (detected organics)													1.09E+02	
Non-Carcinogenic risk - all routes (undetected organics)													1.41E+01	
TOTAL NON-CARCINOGENIC HAZARD INDEX - ALL ROUTES		Sum HI	fraction	0	0.004534032	1.306814953	0.259702702	0	0.111908816	0.066871694	7.189574261	0.011544967	1.24E+02	